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INVENTIONS AT PANAMA.

By STUART F. WELD.

AS the difficulties connected with the Panama enterprise, from at least certain points of view, increase, its advocates dwell even more than hitherto upon the way in which like difficulties were overcome at Suez. Probably no more pointed or liberal recognition of these has appeared than one contained in a speech of Mr. Gladstone in the House of Commons, July 23, 1883. Speaking for the ministry, he said:

"We think it our duty to do justice, as far as lies in our power, to this great canal company, and to its sagacious and energetic projectors. I say that they have claims upon us—claims to respect and honor; for they have conferred a vast benefit upon mankind, and have conferred it by enormous labors, and in the midst of great dangers, under unparalleled difficulties—difficulties which were, unhappily, in some respects due to the unfortunate action of this country in former times."

It is not to be inferred, however, that if such obstacles were successfully overcome, a similar success is to attend the efforts at Panama. Should some sanguine advocate of the enterprise aver that the stockholders were to be as richly rewarded as those of Suez, and within as short a time, we should listen to the prediction with no every-day skepticism, and should insist upon drawing our own conclusions. Many would as readily accept the wonders of the Arabian Nights as trust to estimates of this description. It will not answer to carry too far a similarity, though its existence is not to be denied, between the completed undertaking and the one De Lesseps has now in hand.

But if, from a financial point of view especially, the prospects of the undertaking are not as bright as its advocates might desire, it is

apparent that the company is aware of the difficulties ahead, and is taking what steps under the circumstances are possible. Important announcements were made at the last annual meeting, July 21st. To reduce the ultimate cost, significant changes, De Lesseps stated, had been determined upon. The immense dam, as to which so much controversy has existed, is suppressed. The tide-lock, which was to have been built at the Pacific terminus, is eliminated; also the basin, five kilometres long, at the center of the Isthmus. Nor is the intimation lacking that the dimensions of the channel itself may be reduced. When the president of the company observes that after his inspection of the work, to occur in a few months, he will finally be able to state how the completion of the undertaking is to be effected, one can not but ask whether, to furnish as expeditiously as possible a provisional, serviceable channel, the plan of a lock-canal may not be adopted. Such a solution is not wholly improbable. Subsequently, if the prospects of the enterprise allow, for the above solution the original plan may be substituted; the channel may be cut to the sea-level. The adoption of a lock plan, the summit level to be fed by the Chagres, has been for months, and is still, under consideration by the engineering authorities.

By means of whatever instrumentalities, whether of an engineering or non-engineering type, the company is to proceed with the work, and whatever doubt attaches to the choice of these, none seems admissible as to completion itself. This can hardly be considered a question. Such a view is confirmed by the recent inspection of the work by Lieutenant Charles C. Rogers, U. S. Navy, a brief reference to whose views occurs in an addendum to the present article. While much interest attaches to aspects of the case, which have been referred to—instrumentalities to be employed and the decisions of scientific authorities—there is a question which has not received the attention it deserves, and which is intimately connected with the financial outcome. This it is proposed to examine. How far has the faculty of contrivance and that of invention accelerated the work? How far may it be expected to in future? Such an aspect of the case deserves more attention than many suppose.

The hostility of England to the Suez Canal placed that enterprise for a time in a critical position, by bringing about the abolition of forced labor. But this opposition was in fact the best aid that could have been furnished the undertaking, for it led to the invention of machines which shortened and cheapened the work to a remarkable degree. These inventions have been of service in similar enterprises ever since. Had less efficient devices been brought out at Suez, De Lesseps might well have hesitated before entering upon the more difficult task at Panama. But to meet these more serious obstacles, he possessed mechanical appliances far superior to the rude enginery of 1854. And if, as it is reasonable to anticipate, further radical im-

provements in machines for this kind of work are made, the financial prospects of the Panama Company will not by any such instrumentality suffer.

Inventions are one of the factors of the case. If the French can prove themselves as expert in surmounting difficulties as they were twenty years ago, the confidence with which they still apply themselves to their task will possess a stouter foundation.

The Hon. John Bigelow, in his report to the New York Chamber of Commerce, after his inspection of the work in February, 1886, expresses the opinion that it is upon this factor (inventions) that De Lesseps relies in his anticipations of early success. He adds that De Lesseps's "own remarkable experience"—referring to Suez—has taught him to look with some confidence in this direction. The question of the ultimate success of the French company might possibly hinge upon such a condition.

The French Academy of Sciences, in a report on the Panama enterprise, dated August, 1880, says, "Every great undertaking, properly conducted, brings about improvements in the processes of execution."*

It may not be entirely safe, even in the case of an enterprise running through ten or twelve progressive years, to count on great and radical improvements in the machinery used. On the other hand, such improvements have helped to solve some of the greatest mechanical problems of the century. Such are the Mont Cenis and St. Gothard Tunnels, and the Suez Canal. Will the Panama scheme receive a corresponding help? It is not to be denied that it has already received assistance of this sort. We proprose to consider the question of inventions, as regards each of the engineering works referred to, with reference especially to what has been done and is to be done at Panama.

We will consider, first of all, the tunnels; next, the canals.

Work upon the Mont Cenis Tunnel was begun in 1857, about two years before De Lesseps commenced operations in Egypt. The working parties in the opposite headings, French and Italian, met on Christmas-day, 1870, about a year after the inauguration of the Suez Canal. The St. Gothard Tunnel was begun after the completion of the Mont Cenis, in 1872; the headings met February 29, 1880. The length of the Mont Cenis Tunnel is over seven and a half miles; that of the St. Gothard about nine and a quarter miles. These are the longest tunnels ever constructed.

The invention, by means of which the progress of the work was facilitated, consists in the use of atmospheric air as a motor. By means of water-power, air is reduced to one sixth its ordinary bulk, and the expansive force thus acquired performs the drilling. Owing to the conditions under which tunneling is done, this method is of signal advantage. Each of the Alpine tunnels was excavated through solid

* "Bulletin du Canal Interocéanique," August 15, 1880.

rock, so that blasting was necessary. The use of explosives vitiated the air, while the length of the passage and the impossibility of sinking shafts made the ventilation question a vital one. Had the drills been run by steam, the presence of steam-engines constantly generating smoke and gas would have heated and vitiated the air still further. By the new invention the difficulty was met. The air was compressed outside the tunnel, and conveyed into it by pipes. Here a double purpose was served: by its expansion and liberation the air ran the drills, and ventilated the tunnel. The invention which makes this practicable is called the Sommeiller machine, from the name of the chief inventor.

In an address delivered before the American Geographical Society in December, 1879, Major S. F. Shelbourne referred to the manner in which the work in the Alpine tunnels was accelerated by inventions. The subject of the address was the San Blas route for an interoceanic canal. To construct a canal at this point, it would be necessary to cut a ship-tunnel seven miles long; and it was the purpose of Major Shelbourne to show that the advances made in the mechanical arts during the building of the Alpine tunnels, made a ship-tunnel much more practicable than was supposed. It may be added that, at the time referred to (1879), three competent American authorities—Major Shelbourne, Walton W. Evans, and Frederick M. Kelley—advocated the San Blas route. Of all the routes proposed, it was the shortest, the distance being thirty-three miles from sea to sea, against forty-six at Panama. After the work had been begun at Panama, however, Mr. Kelley, whose interest in the subject was so great that he spent out of his private fortune $120,000 for surveys upon the Isthmus, became an advocate of that undertaking.

Major Shelbourne said:

> In 1863 the progress made in the Mont Cenis Tunnel with hand-drilling, and powder as an explosive, was an average of a foot and a half a day. After they had commenced to introduce power-drilling and the Sommeiller machine, the progress they made was three times greater—that is, four and a half feet per day.

Major Shelbourne next adduced the testimony of Mr. Shanly, the contractor of the Hoosac Tunnel, after observing that in 1872 the Hoosac Tunnel was "in the rush of its progress" under him. Mr. Shanly stated, in 1874: "The use of the machine-drills saved about two thirds of the expense of drilling. The expense of labor would have been, I think, fully three times the cost of machine-drilling." Major Shelbourne next cited the progress effected at St. Gothard, the contract for which was taken in 1872 by Louis Favre, of Geneva:

> In the St. Gothard Tunnel, from 1875 to 1877, with the greater perfection of explosives—for they had come to use nitro-glycerine—and by means of improved drills,* they made a progress of five to one, that is to say, they excavated

* An account of the drills used in the St. Gothard Tunnel may be found in Simms's "Tunneling," pp. 305–320.

their tunnel about five times as fast as was the progress in the Mont Cenis Tunnel in 1863 by hand-drilling. Now, in the years 1878 and 1879, by the general improvement of the whole administration in the St. Gothard Tunnel, they are making a progress of more than eight to one, or about thirteen feet per day, through granitic gneiss in a single heading. So that now, if they can excavate and remove rock from a tunnel eight times faster than they could fifteen years ago, you may readily see how much easier, how much more feasible, a tunnel has become to-day on an isthmus-canal route than at the time, in 1870, when the surveys of Selfridge were made. Indeed, these naval officers in their sphere of action were ignorant of and had not conceived as possible these strides of inventive and engineering skill.*

A few weeks after the address of Major Shelbourne, a paper was read before the American Society of Civil Engineers by Walton W. Evans, in which he described the augmented power of the Sommeiller machine during the excavation of St. Gothard. He said :

"I was shown at the St. Gothard Tunnel steam-drills that by slow motion and high pressures would walk into granite as a knife would into cheese; there was nothing used on the Mont Cenis Tunnel to approach them in efficiency. I was shown air-compressors that kept their great reservoirs, night and day, under pressures of 110 pounds to the square inch, and without difficulty; it was with difficulty and uncertainty that the air-compressors of the Mont Cenis Tunnel could keep the pressure up to 60 pounds to the square inch." He adds: "We are clearly a progressive race, and it would be a wise brain that could predict with certainty what advance may be made by some live Yankee in tunneling machinery when we come to cut a ship-tunnel." †

Mr. Evans was, we may remember, like Major Shelbourne, in favor of the San Blas route, and the tunnel which that route involves.

Certain details as to the machinery used in the Alps may be of interest. After hand-drilling was given up, all the drills used were run by compressed air, but the methods employed to compress it varied. At Mont Cenis hydraulic power exclusively was used. Sommeiller employed at first the fall of a column of water in the same way in which it is applied in the case of the water-ram. Afterward he substituted turbine-wheels. To compress the air at the St. Gothard, ordinary steam-power was at first used.‡ Afterward the improved method of Sommeiller, the turbine-wheel, was substituted. It was found that the amount of water available at the southern terminus was not as large as at the northern; in the former case, accordingly, a higher fall of water was required. A useful or effective fall, as it is

* "Journal of the American Geographical Society for 1879," p. 240. In the exhaustive report upon the canal problem submitted to the Navy Department in 1883 by Lieutenant J. T. Sullivan, extracts occur from the address of Major Shelbourne. He is our best authority as to the San Blas route.

† "Transactions of the American Society of Civil Engineers," 1880, p. 15.

‡ Hence, perhaps, the somewhat ambiguous expression used by Mr. Evans, "steam-drills," though it is possible that "steam" is a misprint for "steel." (?)

called, of 279 feet, was sufficient at the northern end, while at the southern a fall of 531 feet was employed.

The air-compressor used at the St. Gothard had been improved to such an extent by Professor Colladon, of Geneva, that it is often called the Colladon compressor. One of the devices employed was this: The compression of air rapidly generates heat, and to reduce the temperature of the compressing cylinder a circulation of water was kept up all around it. The piston and piston-rod were hollow, and water was introduced into them in like manner. In the shape, finally, of fine spray, water was injected into the cylinder, and thus brought into contact with the air itself.

Not a little interest attaches to circumstances connected with the invention of Sommeiller. This engineer had two associates, Grandis and Grattoni. All were Italians, and all worked together in the evolution of the problem. No statement has appeared designating the part, or significance of the part, taken by each—a fact somewhat to their credit. Of the three, Sommeiller, however, came to be the best known; a member of the Sardinian Parliament, he appeared in public, as his associates did not. His name suggests a French, or, at least, Savoyard origin, but the inventor was a Piedmontese, and in his writings used the Italian tongue.

The St. Gothard Tunnel is by some considered the most remarkable engineering work extant.* Mr. W. W. Evans, already quoted, writing in 1879—and whatever he says upon this point refers to his fixed idea that the proper route for an interoceanic canal was San Blas—says:

> Our weak-kneed people, who get frightened at the idea of a tunnel, should go to Europe, and study tunneling as done there. I found over two hundred tunnels between Nice and Spezzia on the edge of the Mediterranean, cut and used for a very limited railway travel. The line of the St. Gothard Railway is a perfect marvel for tunnels. Nearly one fourth of the whole line is in tunnels. The great or summit tunnel is nine and a half miles long; and in seven places on the line—three on the Swiss side of the St. Gothard, and four on the Italian side—they have tunneled into the sides of the mountain in great entire circles of a thousand metres diameter, merely to get distance and keep the line to their fixed maximum gradient of one in forty, or say one hundred and thirty-two feet to the mile. And what is all this terrible expenditure for? Why, merely to rehabilitate the trade which the Suez Canal has opened, and which the people of the Mediterranean enjoyed, and out of which they built their great cities.†

Whether or not we consider the connection as immediate between Suez and St. Gothard, as our author does, it is to be admitted that the introduction of new processes in the case of these tunnels and consequent acceleration of the work naturally encouraged those, like Mr. Evans and Major Shelbourne, intent upon the cutting of a tunnel for ships. Nor would the larger dimensions of such a work necessarily

* Appletons' "Annual Cyclopædia," 1881, p. 819.

† "Journal of the American Geographical Society for 1879," p. 145.

establish its impracticability. The advocates of San Blas counted upon further advances in the tunneling art, just as De Lesseps has counted upon and witnessed like advances in the art of constructing and operating the excavator and the dredge.

We have considered the way in which inventions expedited the cutting of the two greatest engineering works, probably, ever built to promote communication by land; the two greatest to promote communication by water remain to be considered. The Alpine invention, the air-pressure engine, was not used upon the Suez Canal, nor has it been at Panama. The special kinds of work to which it is adapted are tunneling and mining. There could be no question of a tunnel at Suez. On the other hand, in the plan for a sea-level canal at Panama submitted to the Paris Congress, two solutions were presented. The Cordilleras were to be pierced either by a tunnel or open cut. Tunnels of four or five different lengths were proposed, and calculations submitted; but the congress came to no decision on this point. Had the tunnel plan been adopted, the tunnel would have been excavated by the Alpine method, but subsequently the open-cut plan was adopted, and hand or steam drills instead of air-pressure drills have been employed. Nitro-glycerine, however, which had been substituted for powder during the work at St. Gothard, is largely used.

In considering the two canal enterprises of De Lesseps, we begin with the one completed. As has been said, when, through the intervention of the British and Turkish Governments, the Suez Company had to abandon forced labor, not a little injury was inflicted upon the work. The damage was obviated in part by the indemnity paid by the Egyptian Government, thirty-eight million francs, and in part by the inventions of French engineers. In fact, the company proved to be the gainer. The immense dredges which took such an active part in the rest of the work were contrivances of this period. As to the power and capacity of these machines, we can hardly do better than quote the British historian of the canal, Percy Fitzgerald.* After observing, vol. i, page 202, that the chief contractors, Borel and Lavalley ("men of extraordinary energy and fertility of resource"), came to the task under every disadvantage, and had to establish their workshops and machinery in the desert, he continues:

"They saw at once that the new difficulties as to procuring labor and the limited time allowed by the contract could only be overcome by the aid of machinery of the most daring and novel kind. They accordingly devised those extraordinary dredges which have been the admiration of engineers. . . . No one," he adds, "who has seen an ordinary dredge at its slow work in an English river could have an idea of the bold fashion in which the principle was now applied."

And he thus refers to the general capacity of foreign engineers:

* "The Great Canal at Suez. Its Political, Engineering, and Financial History," 2 vols. By Percy Fitzgerald, London, 1876.

These inventions show the admirable fertility of resource that regulates the work of foreign engineers, who devise machinery to suit the difficulties of each stupendous work; whereas in this country (England) the objection is often made to such undertakings, that engineering does not furnish means to accomplish them. However this may be, the Mont Cenis Tunnel and Suez Canal are excellent instances in point, the difficulties themselves prompting the discovery of means to overcome them.

For a detailed description of the Suez dredges and their appurtenances, Mr. Fitzgerald's work may be consulted, vol. i, pages 203–212. Here we shall only give an account of the principles involved and certain particulars, in which these mechanisms were in advance of preceding ones. The great dredges and excavators employed at Panama go back for their origin to this period. In 1860 an invention was brought out by two engineers, Cavé and Claparède, to facilitate the excavation of canals and cuttings upon railroads. They proposed to use a series of scoops or buckets attached to a revolving, endless chain, and to apply this device both to the ordinary dredge, and to a machine, constructed for the purpose, to be used in dry excavation. This was the origin of the present chain-of-buckets dredge and chain-of-buckets excavator.* The latter machine was first used in France in 1860 upon the Ardennes Railroad, between Sedan and Thionville. In an article in "Le Génie Industriel" for December, 1860, containing cuts of the chain-dredge and chain-excavator, it is said: "Such machines may, above all, be applied to the work on the Suez Canal. They will allow of the reduction in a notable manner of hand-labor, and, in consequence, economize a considerable part of the expense."

This statement was written about eighteen months after work on the Suez Canal was begun; just what the writer anticipated occurred. By one of the contractors, Lavalley, the principle of Claparède was successfully applied to dredges; and the Claparède excavator was in like manner improved by another of the contractors, Couvreux, who built what is called the *excavateur Couvreux*. He took a contract for excavating the seuil d'El Guisr, a ridge which crosses the line of the canal for a space of ten miles, its highest points being sixty-five feet above the sea. This work was finished six months inside the contract time, a result to be ascribed in part to the Couvreux excavator.

One of the improvements introduced by Couvreux consisted in inserting movable bottoms in the buckets. In clayey and adhesive soils the buckets sometimes clogged, so that much time was required to clear them. By the new arrangement the bottom was forced forward, and the clearance thus effected. The bucket having descended, a fresh load of earth drove the bottom into its original place. An article in "La Propagation Industrielle" for September 1, 1868, illus-

* This principle, it is true (the use of the endless chain), was applied to a certain extent in the case of dredging, both in France and England, early in the century. (See Knight's "American Mechanical Dictionary," vol. i, pp. 747, 748.)

trated by cuts, describes this contrivance, and also another of the improvements of Couvreux. These applied, by-the-way, to the buckets and chains of dredges as well as to those of excavators.

Professor J. E. Nourse, U. S. Navy, in his report on the Suez Canal, published in 1884, says (p. 69) with reference to the French excavator:

> In 1865 Couvreux invented a dry dredger which he called the *excavateur chargeur*. This was a dredger mounted on a car which ran on a tramway parallel with the canal. Its chains and iron buckets descended to scoop up the sand, emptying it into cars, which were themselves drawn up to the summit of the embankment along a succession of tramways.

In the above extract the method is designated by which the earth scooped up by the excavator is got rid of—that is, by means of dirt-cars on common tracks. The methods by which the earth brought up by dredges was disposed of were three in number: By the first the sand was emptied into a hopper and thence conveyed through a duct, two hundred and twenty feet long, to and beyond the banks. Steam-pumps injected water into the hopper, thus facilitating the discharge. Such a dredge was called a *drague à long couloir*. At times the banks were too high to admit of this process, and recourse was had to the second method, a mechanism called the *élévateur*. It consisted of an elevated railroad, supported by iron posts, partly upon the bank and partly upon a barge between the bank and dredge. Sometimes the dirt-cars carried the earth to a height of fifty-six feet. The cars were attached to an endless chain, and passing upward along the road were emptied, and returned underneath the track. Cuts of these parts of the machinery may be found in Professor Nourse's report already referred to. The third method was the common one of barges or lighters. These were furnished with engines, and carried their contents either to lakes along the line of the canal, or near either terminus, to the sea, and were emptied by means of under- or side-doors.

While, in executing an undertaking like that at Suez, the work consists chiefly in digging, certain parts require to be built up in the proper sense of the term. It was necessary to establish upon the Mediterranean an artificial harbor, and two jetties were constructed. Here was founded the city of Port Said. In the construction of these piers we have an example of the way in which the adversaries of the undertaking asserted, without any sufficient basis, the impracticability of the work. The "Edinburgh Review," referring to the construction of the jetties, said: "Any constructions attempted so as to form an entrance for the canal will be swallowed up. Every block, every stone, will be swallowed up, and we shall not see a single one above water." Mr. Fitzgerald quotes this passage. Referring in particular to the western pier, supposed to be specially difficult of construction, because it was to arrest large bodies of sand moving at this

point of the coast from west to east, he says it had been again and again pronounced impossible to build it, because stone was not to be obtained. There were no quarries, it was alleged, nearer than Lake Timsah or Suez, and quarry-stones could not be dragged one hundred or even fifty miles across the desert. It turned out that there were quarries near Alexandria, whence the stone might have been brought by sea. The contractors, however, as the historian of the canal tells us, "fell back on their own resources"; they manufactured the stone on the spot. The artificial blocks thus compounded were two thirds sand and one third hydraulic lime. Each weighed over twenty tons, and nearly thirty thousand were manufactured and tumbled into the sea. We are assured that "the whole has continued as firm as any structure of the kind in Europe, and is consolidating with every year."

The not carefully considered prediction of the "Edinburgh Review" is almost without significance when compared with others made in the House of Commons by Robert Stephenson and Lord Palmerston. If not the first, Mr. Stephenson was one of the first, of English engineers. In a debate, in June, 1858, Lord Palmerston referred to the scheme as "the greatest bubble that had ever been sought to be imposed on the credulity of the public." The canal, Mr. Stephenson averred, was "physically impossible." It was a mistake to talk of a canal. "It would be simply a ditch. . . . How could a canal be dug eighty miles long, without drinking-water along its course?" But the project, supposed to be so impracticable, did not deserve this sort of treatment. Within thirteen years of inauguration it paid seventeen per cent. That such predictions were falsified, and in so signal, even grotesque a fashion, was due, in part at least, to the inventive capacity, the constructive talent, which the undertaking called forth. Upon Lavalley and Couvreux, as well as upon De Lesseps, it devolved to show that ditches might be made serviceable, and a financial "bubble" converted into an astonishing success.

The part of our subject now examined serves, strictly speaking, as an introduction to what in a special sense we have to consider—the work at Panama and connection of inventions with it. Of the three enterprises to which attention has been directed, one—that at Suez—bears a close analogy, both as to the use for which it was built and the character of the machinery employed, to the enterprise at Panama. Such an analogy we do not meet, if we set alongside the case of the tunnels and that of the American enterprise, although from one point of view the work in them resembled more closely that at Panama than that at Suez. In the case of the tunnels, blasting was the regular process, hardly a foot was excavated without it; and a very considerable amount of blasting is required at Panama. Visitors to the works have in fact compared the explosions heard for miles along the excavation to musketry-discharges in battle. In respect to the

use of explosives, then, an analogy exists between the Alpine and Panama undertakings. The introduction of nitro-glycerine proved in both cases of great advantage. At Suez, on the other hand, the occurrence of rock was rare, and blasting was resorted to only in exceptional cases.

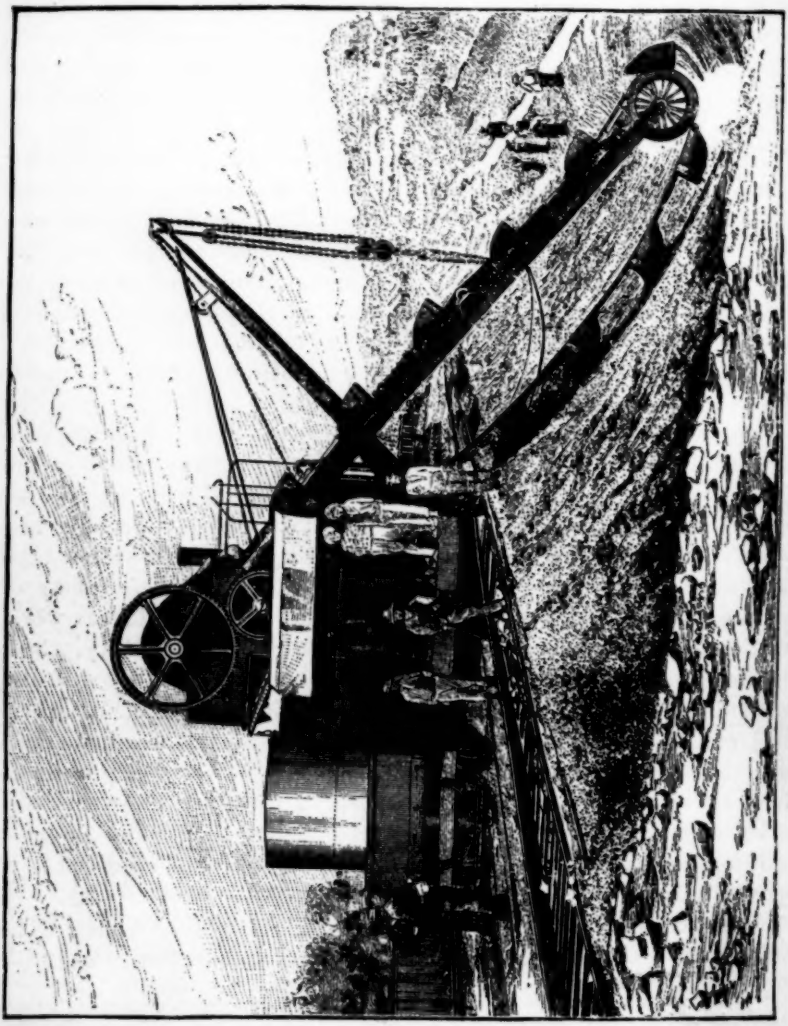
While from such points of view analogies may be apportioned among the enterprises—two railroad and two ship-canal enterprises—which occupy us, it may not be denied that the work at Panama and machinery used for it bear a special resemblance to those at Suez. Nor may we lose sight of the fact that from an extra-scientific point of view, one individuality, one firm resolve, have, rather than other human agencies, accomplished in each case whatever has been done. As regards the enterprise first carried through, we have considered some of the advances made in the engineering and mechanic arts. To say that these have contributed to the feasibility of the work at Panama is to say but little. They alone, perhaps, have rendered it possible. But for them, the Paris Congress might not have been held; the Panama work might not have been even begun, still less in process of execution.

We come, finally, to the question of inventions in immediate connection with Panama. These seem to consist, thus far, chiefly in an increase in the size and power of the machines, whether dredges or excavators, employed. But ingenuity may at any time supply any need that develops itself, and it has effected part of what has been done already. An opinion formulated by the French Academy of Sciences in 1880, regarding inventions in connection with such work, has been quoted. Lieutenant N. B. Wyse, of the French Navy, whose plan for a sea-level canal was adopted by the Paris Congress, has also touched upon this point. He refers to objections urged against a sea-level canal. The plan involved either a huge tunnel or a huge open cut; in either case the work would be much in excess of any of a like character hitherto attempted. He says, "The course of events, experience based upon precise observation, will undoubtedly suggest new processes, or processes scarcely caught sight of at the present day, so as to conquer the difficulties indicated."*

Such anticipations have not been entertained without cause. The major part of the excavation has not yet been done, but already the

* "Rapports sur les Études de la Commission Internationale d'Exploration de l'Isthme Américain, par Lucien N. B. Wyse," p. 56. Whatever the services of Lieutenant Wyse in the surveys of the Isthmus, between 1876 and 1879, it should be remarked that his work, published last year, "Le Canal de Panama," is not to be read without allowances. The rupture which occurred between himself and De Lesseps in 1880, due to the fact that Wyse, as he himself tells us, expected to be appointed director-general of the work, and was not so appointed, has led to acrid criticisms on his part upon the company. That part of his work which relates to his surveys—the larger part—possesses not a little interest, and is not perhaps open to much criticism; but, as regards his strictures upon the company, the fact referred to is to be kept in mind.

mechanisms used have been brought to a state of efficiency—one could not say perfection—never reached in the case of any other undertaking. In attempting to trace how this has been brought about, we may begin with one of the first of the new processes introduced, the American method of boring to test the strata and use of the diamond-drill. In



FRENCH EXCAVATOR (from Lieutenant Kimball's Government Report).

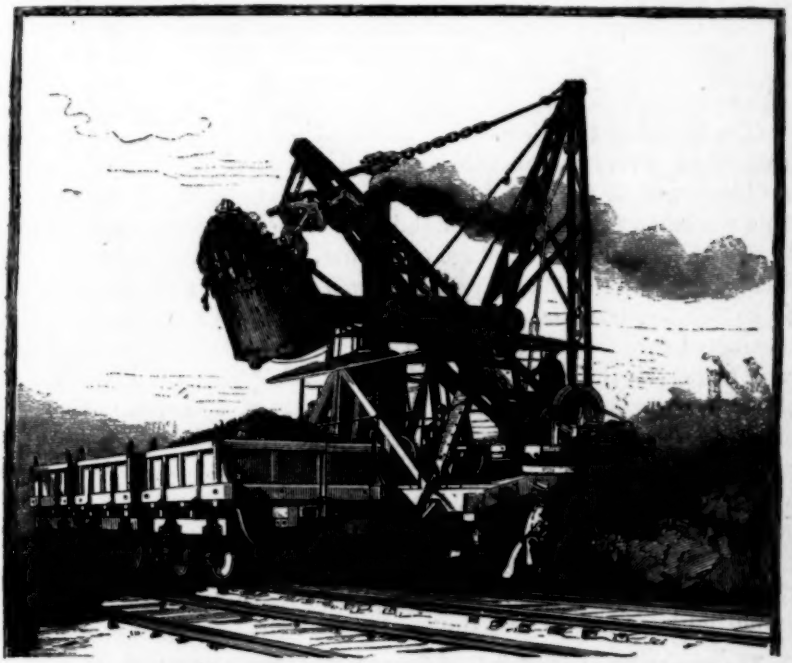
September, 1883, the director-general of the works, Dingler, gave an address in Paris upon the then condition of the enterprise, in which he says:

For the great cutting we have made a large number of American soundings. The Americans in this special matter have made considerable progress, and have rendered us very great service.

Ordinarily, when soundings are made, the yield is brought up in a pulver-

ized state, so that the engineer is obliged to make many conjectures as to the quality of the rock, in order to know what slope to give the excavation.

Generally one is much puzzled. The Americans have discovered a method of bringing up the rock itself in a shape large enough to admit of our judging as to its hardness. A *carrot*, as the workmen call it, is fetched up. It is obtained by means of a cylinder armed at its lower extremity with black diamonds. This is given a rapid rotary motion; it descends and penetrates into the rock, and in this way we can bring up a block which furnishes the exact consistency of the strata. We placed, before the eyes of the commission,* this morning, a box of specimens taken in Culebra. The result is, that we have a perfect knowledge of the ground, and it is these soundings which enable us to fix our prices.



American Excavator (reduced from cut in "Scientific American").

The following reference to these American soundings occurs in Admiral G. H. Cooper's report to our Government on the progress of the work, dated March 2, 1883. After observing that soundings to ascertain the nature of the soil had been made all along the line, he says:

The first of these soundings were made by French engineers, with the old-fashioned drill and spoon to bring up specimens. This method took many months and was very unsatisfactory; and, finally, the contract for making the remaining soundings was given to Mr. George R. Burt, an American, who is connected with the Panama Railroad Company. Mr. Burt has used the American diamond-drill, and with it has accomplished more work in the past three months than had been done by the other method in the previous two years.

* The "Commission consultative" of engineers.

The connection is so close between the consistency of the strata and the slope of the cutting, that the following as to this point will be of interest. The director-general continued:

Well, these borings, made in large numbers at Culebra, showed us that we had to excavate a rock, semi-hard, schistous in quality, having nearly horizontal strata, and that the earth was dry. The result is, that one could not desire better earth for a work of such an exceptional character. We shall be obliged, manifestly, to be very prudent. Accordingly, at the top we have opened the cutting, as if the slope was to be a gentle one. We remove the clayey part which, under the action of water, can be brought to the consistency of paste or mud. Here we have made a very ample opening. But in proportion as we reach clear rock, we make the prism narrower, so as to comprise the cubic contents strictly necessary, with the purpose to make the slope more gradual should experience require it.

The bringing together by an undertaking such as Panama of contractors of divers nationalities, naturally leads to the use of various machines, and it remains to be seen what advantage is to be derived from the sort of rivalry thus established. Here the Panama work may be said to possess an advantage over Suez. The latter was almost exclusively in the hands of French engineers, and was carried through by French contractors and inventors. A single Englishman, Ayton, contracted for a considerable part of the work, but he became bankrupt owing to the withdrawal of forced labor, and the French were obliged to assume his portion.* In the case of Panama, contractors of several nationalties have been employed—French, English, Dutch, Swedes, Swiss, Italians, Americans, and Colombians. The "Canal Bulletin" for February 15, 1885, contains a table of contracts, arranged according to nationality, entered into at the time.

After treating of the American use of the diamond-drill, the director-general proceeded to speak of some of the other machines employed.† He said:

The excavation is effected in different ways. We are very *eclectic* at Panama. We reject no system, no method, and as the earth varies at every step, as the works at one point do not resemble those at another, we can try different ways. At certain places we have mellow earth, which is generally composed, in the valleys, of clay mixed with a feldspathic sand. In such places we can make the attack by mechanical processes. We employ excavators.

There are two sorts of excavators, the French and American. The American excavators are very ingenious, and in mellow soil they give satisfactory results. The French excavators are of a type already tested in many places. In clayey and rather adhesive earth they seem preferable. Accordingly, the American papers, knowing, not that we had declared as much, but that facts had

* Fitzgerald's "Suez Canal," vol. i, p. 200.

† The diamond-drill has recently been put at Panama to a use other than prospecting. The apparatus of the American Diamond-Drill Company is employed to blast rocks under water. Dynamite is the explosive used, and the rock is so thoroughly shattered that a dredge readily removes it. (See "Canal Bulletin," January 15, 1887.)

demonstrated this superiority, engaged in a little controversy in which patriotism was mixed up. Finally, I wrote to the American contractors that I had never come to any prejudiced decision, that I was wholly disposed to make use of their skill, which I acknowledged to be incontestable, and of their great experience in public works.*

The essential difference between the French and American excavator is as follows: The French, as has been said, carries a series of buckets attached to an endless chain. The American—with which Americans are comparatively familiar—has a single bucket; it is larger than the French buckets, and is worked at the end of a lever. The French buckets, though smaller, revolve rapidly; their number and constant motion compensate perhaps for their size. Cuts of each system are annexed. It may be remarked as to French excavators, that sometimes the buckets ascend filled with earth *below the bucket-ladder*, as in the cut, and sometimes, the motion of the chain and position of the buckets being reversed, *above it*. The cut of the French excavator is a reduced cut of an illustration in Lieutenant Kimball's government report. That of the American excavator, also that of the American dredge, found farther on, are reduced from illustrations which appeared in "The Scientific American" in 1884 and 1886. The principle of the French excavator is applied with differences of detail in several ways. There are, or have been recently, at work at Panama the following French or Belgian excavators—named respectively after the manufacturer or designer, Ville-Châtel, Evrard, Weyer et Richemond, Gabert, Boulot, Demange, and Andriessen. There were of the American excavator two types, the Osgood and Otis.

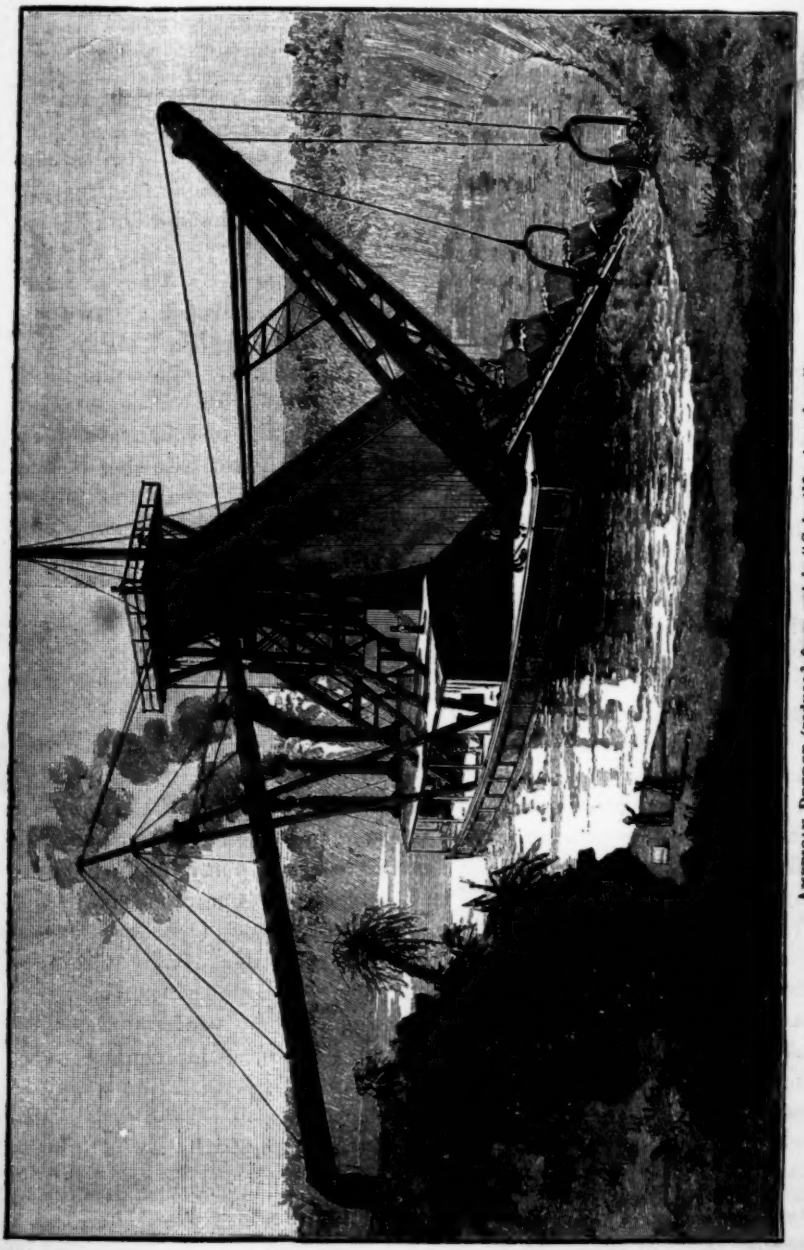
The director-general, after this reference to excavators, observed that in rocky parts excavators could not be used.

In rock excavation a method has recently been tried of breaking up masses of rock by powder and dynamite combined. An explosion of this kind was witnessed by De Lesseps and the party which accompanied him in February, 1886. In a subsequent communication to the French Academy of Sciences,† he gave an account of the wreck of a mass of porphyry amounting to thirty thousand cubic metres, on this occasion. The charge consisted of two parts dynamite to one of powder. Some idea of the force of the explosion may be derived from the pains taken to block the passage which led to the charged chamber. For the space of thirty feet it was packed with masonry. Upon a public occasion soon after, De Lesseps held up a fragment of the rock dislocated, observing that here was one-billionth part of it!

* Lieutenant W. W. Kimball, United States Navy, in his report to our Government, after his inspection of the canal in January, 1886, claims that the American excavator excels in stony soil and surface soil with roots, while the French machine is better in light soils and sand. The officer of our navy who inspected the works last March, Lieutenant C. C. Rogers, who has been referred to elsewhere, confirms this.

† "Bulletin du Canal Interocéanique," May 1, 1886.

The advantage of using powder and dynamite combined is thus explained. If dynamite alone were used, the breakage would be carried



AMERICAN DREDGE (reduced from cut in "Scientific American").

too far; the fragments could not be as conveniently loaded by cranes. The effect of powder would be to project the fragments too far, thus damaging, it might be, the neighboring works. As regards the use of

dynamite, we might query whether, if a still stronger explosive were employed, the rock might not be reduced to pebbles or sand. In this state it might be handled by the buckets of excavators, and the slower operation of cranes be avoided. We might speculate further, whether the explosives said to have been recently invented in France and Germany, or like substances, might not be of service. If, as is understood, the governments which possess them desire to keep the process of manufacture secret, some difficulty might be experienced in procuring them. But civilization might be the gainer if such inventions were used to blast a thoroughfare at Panama instead of to enhance the rapidity with which human slaughter is carried on.*

Of all writers who have interested themselves in the Panama Canal no one has given the amount of attention to inventions bestowed by Mr. Bigelow in his report to the New York Chamber of Commerce. We can not do better than give his views upon this topic. These, again, may serve to introduce further particulars as to the machinery employed. After observing that the wages of unskilled labor when work was begun were ninety cents a day, and have since advanced to a minimum of $1.75, and that even at this price the company does not readily get the labor needed,† he says:

The question then arises, Must the work be prosecuted under the present conditions?

"When the Jews were required to make brick without straw, Moses came. May not the exigency, like child-bearing, work its own cure?

In all ages and nations, when manual labor has become too costly to do the work for which there was a universal or even a general need, a substitute for it has been promptly devised. It was to the need of economizing muscular labor that we owe the hoe, the wheelbarrow, and the plow. Had laborers' wages never risen above a shilling a day, we should never have heard of McCormick's reaper, or of Howe's and Singer's sewing-machines. It is equally certain that the portion of our planet which lies under the tropics will never play the part in human history to which its territorial extent and productive power entitle it, until our present assortment of mechanical substitutes for muscular power has been very largely increased. Machines do not mind malaria; they are not poisoned by marshy water; they thrive on the black-vomit; they have no fear of chills or sunstrokes; and, what is more, they are never tired, and will work all the days and nights of their natural lives without interruption, if properly fed and cared for.

That is the class of operatives for out-of-door work in the tropics, and it is to them that M. de Lesseps must, and I presume does, look for an early completion of his canal; for it is in that direction his own remarkable experience

* No secret seems to attach to the composition of a new explosive, bellite, to which an article is devoted in the "Scientific American," May 14, 1887. This explosive, it is stated, has been found more effective in quarries than any nitro-glycerine compound.

† One of the chief difficulties of the company at present is getting an adequate labor-supply. In the "Canal Bulletin," June 16, 1887, the fact is noticed that at several points part of the machinery provided was lying idle, owing to this lack. Several hundred Chinese had arrived but recently, and it was hoped that their labor would prove as effective as that of the Chinese employed upon the Panama Railroad forty years since.

has certainly taught him to look with some confidence. When the work on the Suez Canal was begun, and under climatic conditions much the same as those at the Isthmus of Panama, the Suez Canal Company was entitled by its charter to as many native laborers as it required up to forty thousand, and at an almost nominal price. As these men were drafted into the company's service by *corvée*, England protested against a "revival of slavery" in Egypt. The Khedive was constrained to break his contract with the company, for which he had afterward to pay an indemnity of thirty-eight million francs, and M. de Lesseps had the mortification of seeing his little army of twenty thousand fellahs dispersed as suddenly and as irrevocably as an April fog.

The logic of the situation promptly suggested the replacing of the men with machines; the putting of slaves without souls or sensibilities in the place of slaves with both. The inventive genius of his countrymen was stimulated by the gravity of the crisis, and in due time from eighty to one hundred dredges, with an appropriate supply of barges, elevators, steam-tugs, locomotives, etc., had taken the place of a large portion of the men withdrawn; and this machinery, with only four thousand men, increased the monthly output from ten thousand cubic metres to two million, and executed more excavation in the last three years of the work than had been done in the previous seven. May not the scarcity and cost of manual labor on the Isthmus in like manner develop the means of dispensing with at least that portion which the labor market will not cheerfully supply?

The results already accomplished in that direction justify the expectation that, to a considerable extent, it may. There are already at work on the Isthmus machines for dredging and for excavation, far more powerful and efficient than any ever used on the Suez Canal or anywhere else.

It is the opinion of Mr. Bigelow that De Lesseps's "remarkable experience" at Suez has led him to anticipate the forwarding of the Panama work by similar means. This expectation is illustrated by an incident of the Paris Congress. Lavalley, the inventor of the dredges, was there—was in fact a member; and to him De Lesseps referred at one of the sittings as an engineer "who had already invented so many machines, and who, under similar circumstances, would know how to invent more."

Mr. Bigelow observes, with regard more especially to excavaters, "There is no reason to suppose that, in the creation of such machines, art and science have reached a limit in any direction." One might say with Arago:

> "Croire tout inventé n'est qu'une erreur profonde;
> C'est prendre l'horizon pour les bornes du monde."

We can not suppose that an horizon of inventive impossibilities has settled down about Panama.

With regard to Mr. Bigelow's statement that there are at work machines for dredging and excavation "far more powerful" than any ever used elsewhere, it has been already stated that the greater power of these mechanisms is chiefly due to their increased dimensions and the higher steam-power employed. Let us take the "City of New

York," the greatest dredge probably ever constructed; built by the American Contracting and Dredging Company, and by them used at Panama. The engines of the largest Suez dredges had a force of seventy-five horse-power. Those of the "City of New York" have a force of three hundred. To run all parts of the complicated machinery, no fewer than eight are employed. The huge ladder which carries the buckets is one hundred and ten feet long; the chain to which the buckets are immediately attached, if ruptured, would reach from the top to the bottom of Bunker Hill Monument. Two discharge-pipes, each three feet in diameter and one hundred and eighty feet long, carry the earth to the banks. By means of steam-pumps, as in the case of the Suez dredges, water is forced into the bell or hopper, and the discharge facilitated. The effectiveness of this mechanism is not due solely to its construction on an enlarged scale; contrivance comes in for part of the credit, and has effected part of the result. One of the peculiarities of the American dredges may be referred to. To steady the vessel and hold the buckets against the bank, two spuds or pile-anchors are employed. In the case of the "City of New York" these spuds are sixty feet high and two feet in diameter. They pass through the hull, one on each side, and the iron chisel-point at the termination of each weighs eighteen hundred pounds. This is planted in the bottom. When spud No. 1 descends, it serves as a pivot around which the dredge, carrying the bucket-ladder in operation, slowly revolves, thus traversing the arc of a circle. When No. 1 is raised, No. 2 is lowered, and serves in like manner as a center. After this fashion, planting a foot at a time, this huge digging, spouting creature, as one might term it, advances. The movement through an arc is regulated by two distance-lines, so called. These are attached to windlasses, one on each side of the forward deck, the other end being attached to the shore. As one line is drawn in, the other is paid out, and by this simultaneous process the motion in curves is maintained.* A high degree of interest attaches to a structure combining power, ingenuity, and complexity as these are not united in any other mechanism of the sort. Such among contrivances of the kind is the "City of New York."

With regard to the amount of excavation effected by the dredgers of the American Company, Mr. Bigelow sets it down as about double the largest output of any machine at Suez. Lieutenant Kimball, comparing the output of the later American dredges with the best at Suez, sets it down as more than double, twelve hundred cubic metres per hour, as compared with four hundred and eighty.

While in the matter of dredges Americans have contributed of late more than others by fresh devices and an increase of dimensions, the French seem to have effected like results with regard to excavators.

* For these particulars as to the working of the spuds, etc., the writer is indebted to Lieutenant W. W. Kimball, U. S. Navy.

Those first employed at Panama had a force of twenty-four horse-power, while the powerful machines more recently sent out have a force of ninety. The French have lately employed in connection with their excavators a mechanism similar to the *élévateur*, already described. It is called the *transporteur*, and consists of an elevated structure which performs the same service for an excavator that the *élévateur* does for a dredge. The earth is deposited from the buckets upon an endless belt. This passes round two drums about two hundred feet apart, and in the interval rests upon friction-rollers. The earth is thus carried outward from the excavation, and at the same time upward.

While, owing to the power and size of her digging mechanisms, the Panama undertaking has quite an advantage over Suez, it is not to be assumed that this advantage may not be further increased. Upon this contingency the decision of important questions may depend. Whether the canal be finished, at least provisionally, as a lock-canal or cut immediately to the sea-level, is possibly one of these. But the decision as to locks will have to be expeditiously arrived at; and if inventors are to step in and affect in any sort of way the result, they have not much time for contrivance and experiment. At all events, we may hope much from the fact that the undertaking is probably in the best hands to which it could have been intrusted. Owing to the completion of former contracts, or the substitution of later for earlier ones, the greater part of the work devolves at present upon French or American contractors. The portion undertaken by the American company consists, it is true, wholly of dredging—the easiest part of the work. There can be no doubt as to the satisfactory, and, should it prove necessary, rapid completion of this part of the undertaking; the chief difficulty lies in the excavation of dry earth and rock, and this is chiefly in the hands of the French.* But American inventions and skill may be as serviceable here as in any other section of the work. It is a pledge of earnest effort that the two republics which have the work in charge have also a greater stake than others in the completion of the undertaking—France, because French capital has furnished the funds; America, because of our need of a

* According to the plans of the company, as described recently by Charles de Lesseps, Vice-President of the Suez and Panama Companies, part of the work which it was thought must be done by excavators may be effected by dredging. With this end in view, he tells us, the company is making preparations. It is proposed to introduce into the works, between Gamboa and Paraiso, the waters of the upper Chagres. An analogous plan served the same purpose at Suez: fresh water was introduced from the Nile; nine dredges were carried up by a lock and floated upon it. These operated upon a temporary lake, whose level was seventeen feet above the Mediterranean. Whether such a plan, by some thought impracticable, may be successfully applied at Panama, remains to be seen.

For a description of the manner in which the Nile water was employed, see Fitzgerald, vol. i, pp. 190–194.

shorter water-way between our Atlantic and Pacific coasts. And certainly no other nations offer greater achievements in inventions and execution as a guarantee of success.

Nothing, perhaps, so strongly characterizes this century as the advance man is making in exploring, understanding, and obtaining a mastery over Nature. This process of mastery could scarcely proceed in a more instructive way than by tracing its stages in the instances we have considered. The Alps and the two Isthmuses illustrate it in a not unfitting way. It is safe, probably, to say that the power to excavate earth, to excavate and blast rock, is from five to ten times as great as when a man, wholly unknown to fame, landed with a handful of his countrymen where the city of Port Said now stands and began the excavation of Suez.

In regard to the present enterprise upon the American Isthmus, if we take into account its magnitude and the difficulties involved, it represents without doubt the greatest effort in the line of industry and peaceful achievement man has yet put forth. De Molinari, the Belgian economist, computed that the stock of machinery for the excavation represented the labor of half a million men. Such a fact indicates how far the process of conquering Nature has been carried. The world is watching, with no doubt a degree of skepticism, the way in which the remaining work is being done; and in scientific circles especially an eager interest will continue to be manifested in this great struggle of skill and inventive genius against the forces and obstinacy of Nature. It may be protracted, but it must be in the end successful.

ADDENDA.—In the article in "The Popular Science Monthly" for July, entitled "The Panama Canal," a statement occurs, page 329, with reference to a report to the Navy Department by Lieutenant C. C. Rogers upon the state of the work in March. This statement is not in all respects correct. The foot-note in which it occurs was based upon a dispatch from Washington, not seen by the writer until after the proof-sheets had been returned. Subsequently a rectified statement was obtained from Lieutenant Rogers. As the views of the latter are soon to be given to the public in full—not a few await them with interest—and probably in advance of the publication of the present article, no special importance attaches to a correct statement here of his positions. The writer quotes, however, with the permission of Lieutenant Rogers, the following from a letter in which he defines his views. The passage quoted refers, not to the chances of the completion of the canal (for its completion Lieutenant Rogers thinks more than probable), but to the chances of its completion by the present company. As regards the dispatch already referred to, he says: "The reporter has called largely upon his imagination in saying that I doubt whether the French company will be able to complete the canal. If the new loan be wisely spent, and a good showing results, their chances for so doing will be good; for the necessity of finishing the work will be apparent." Respecting statements frequently set afloat as to alleged mismanagement, and likewise the company's chances of success, he adds: "One who thinks that the officers do not realize the question in its true aspect, who regards the engineers as inefficient, and the whole company as blind, is in great error. If they do as well in the next eighteen months as during the past year, their chances of completing the canal will be more than good."

SCIENCE AND PRACTICAL LIFE.*

By Professor T. H. HUXLEY.

THE middle of the eighteenth century is illustrated by a host of great names in science—English, French, German, and Italian—especially in the fields of chemistry, geology, and biology; but this deepening and broadening of natural knowledge produced next to no immediate practical benefits. Even if, at this time, Francis Bacon could have returned to the scene of his greatness and of his littleness, he must have regarded the philosophic world which praised and disregarded his precepts with great disfavor. If ghosts are consistent, he would have said: "These people are all wasting their time, just as Gilbert and Kepler and Galileo and my worthy physician Harvey did in my day. Where are the fruits of the restoration of science which I promised? This accumulation of bare knowledge is all very well, but *cui bono?* Not one of these people is doing what I told him specially to do, and seeking that secret of the cause of forms which will enable men to deal, at will, with matter, and superinduce new natures upon the old foundations."

But, a little later, that growth of knowledge beyond imaginable utilitarian ends, which is the condition precedent of its practical utility, began to produce some effect upon practical life; and the operation of that part of Nature we call human upon the rest began to create, not "new natures," in Bacon's sense, but a new Nature, the existence of which is dependent upon men's efforts, which is subservient to their wants, and which would disappear if man's shaping and guiding hand were withdrawn. Every mechanical artifice, every chemically pure substance employed in manufacture, every abnormally fertile race of plants, or rapidly growing and fattening breed of animals, is a part of the new Nature created by science. Without it, the most densely populated regions of modern Europe and America must retain their primitive, sparsely inhabited, agricultural or pastoral condition; it is the foundation of our wealth and the condition of our safety from submergence by another flood of barbarous hordes; it is the bond which unites into a solid political whole, regions larger than any empire of antiquity; it secures us from the recurrence of the pestilences and famines of former times; it is the source of endless comforts and conveniences, which are not mere luxuries, but conduce to physical and moral well-being. During the last fifty years, this new birth of time, this new Nature begotten by science upon fact, has pressed itself daily and hourly upon our attention, and has worked miracles which have modified the whole fashion of our lives.

* From "The Advance of Science in the Last Half-Century." New York: D. Appleton & Co. 1887.

What wonder, then, if these astonishing fruits of the tree of knowledge are too often regarded by both friends and enemies as the be-all and end-all of science? What wonder if some eulogize, and others revile, the new philosophy for its utilitarian ends and its merely material triumphs?

In truth, the new philosophy deserves neither the praise of its eulogists nor the blame of its slanderers. As I have pointed out, its disciples were guided by no search after practical fruits, during the great period of its growth, and it reached adolescence without being stimulated by any rewards of that nature. The bare enumeration of the names of the men who were the great lights of science in the latter part of the eighteenth and the first decade of the nineteenth century, of Herschel, of Laplace, of Young, of Fresnel, of Oersted, of Cavendish, of Lavoisier, of Davy, of Lamarck, of Cuvier, of Jussieu, of De Candolle, of Werner, and of Hutton, suffices to indicate the strength of physical science in the age immediately preceding that of which I have to treat. But of which of these great men can it be said that their labors were directed to practical ends? I do not call to mind even an invention of practical utility which we owe to any of them, except the safety-lamp of Davy. Werner certainly paid attention to mining, and I have not forgotten James Watt. But, though some of the most important of the improvements by which Watt converted the steam-engine, invented long before his time, into the obedient slave of man, were suggested and guided by his acquaintance with scientific principles, his skill as a practical mechanician, and the efficiency of Bolton's workmen, had quite as much to do with the realization of his projects.

In fact, the history of physical science teaches (and we can not too carefully take the lesson to heart) that the practical advantages, attainable through its agency, never have been, and never will be, sufficiently attractive to men inspired by the inborn genius of the interpreter of Nature, to give them courage to undergo the toils and make the sacrifices which that calling requires from its votaries. That which stirs their pulses is the love of knowledge and the joy of the discovery of the causes of things sung by the old poets—the supreme delight of extending the realm of law and order ever further toward the unattainable goals of the infinitely great and the infinitely small, between which our little race of life is run. In the course of this work, the physical philosopher, sometimes intentionally, much more often unintentionally, lights upon something which proves to be of practical value. Great is the rejoicing of those who are benefited thereby; and, for the moment, science is the Diana of all the craftsmen, But, even while the cries of jubilation resound and this flotsam and jetsam of the tide of investigation is being turned into the wages of workmen and the wealth of capitalists, the crest of the wave of scientific investigation is far away on its course over the illimitable ocean of the unknown.

Far be it from me to depreciate the value of the gifts of science to practical life, or to cast a doubt upon the propriety of the course of action of those who follow science in the hope of finding wealth alongside truth, or even wealth alone. Such a profession is as respectable as any other. And quite as little do I desire to ignore the fact that, if industry owes a heavy debt to science, it has largely repaid the loan by the important aid which it has, in its turn, rendered to the advancement of science. In considering the causes which hindered the progress of physical knowledge in the schools of Athens and of Alexandria, it has often struck me* that where the Greeks did wonders was in just those branches of science, such as geometry, astronomy, and anatomy, which are susceptible of very considerable development without any, or any but the simplest, appliances. It is a curious speculation to think what would have become of modern physical science if glass and alcohol had not been easily obtainable; and if the gradual perfection of mechanical skill for industrial ends had not enabled investigators to obtain, at comparatively little cost, microscopes, telescopes, and all the exquisitely delicate apparatus for determining weight and measure, and for estimating the lapse of time with exactness, which they now command. If science has rendered the colossal development of modern industry possible, beyond a doubt industry has done no less for modern physics and chemistry, and for a great deal of modern biology. And as the captains of industry have, at last, begun to be aware that the condition of success in that warfare, under the forms of peace, which is known as industrial competition, lies in the discipline of the troops and the use of arms of precision, just as much as it does in the warfare which is called war, their demand for that discipline, which is technical education, is reacting upon science in a manner which will, assuredly, stimulate its future growth to an incalculable extent. It has become obvious that the interests of science and of industry are identical; that science can not make a step forward without, sooner or later, opening up new channels for industry; and, on the other hand, that every advance of industry facilitates those experimental investigations upon which the growth of science depends. We may hope that, at last, the weary misunderstanding between the practical men who professed to despise science, and the high-and-dry philosophers who professed to despise practical results, is at an end.

Nevertheless, that which is true of the infancy of physical science in the Greek world, that which is true of its adolescence in the seventeenth and eighteenth centuries, remains true of its riper age in these latter days of the nineteenth century. The great steps in its progress have been made, are made, and will be made, by men who seek

* There are excellent remarks to the same effect in Zeller's "Philosophie der Griechen," Theil. II, Abth. ii, p. 407, and in Eucken's "Die Methode der Aristotelischen, Forschung," pp. 138, *et seq.*

knowledge simply because they crave for it. They have their weaknesses, their follies, their vanities, and their rivalries, like the rest of the world; but whatever by-ends may mar their dignity and impede their usefulness, this chief end redeems them.* Nothing great in science has ever been done by men, whatever their powers, in whom the divine afflatus of the truth-seeker was wanting. Men of moderate capacity have done great things because it animated them; and men of great natural gifts have failed, absolutely or relatively, because they lacked this one thing needful.

To any one who knows the business of investigation practically, Bacon's notion of establishing a company of investigators to work for "fruits," as if the pursuit of knowledge were a kind of mining operation and only required well-directed picks and shovels, seems very strange.† In science, as in art, and, as I believe, in every other sphere of human activity, there may be wisdom in a multitude of counselors, but it is only in one or two of them. And, in scientific inquiry, at any rate, it is to that one or two that we must look for light and guidance. Newton said that he made his discoveries by "intending" his mind on the subject; no doubt truly. But to equal his success one must have the mind which he "intended." Forty lesser men might have intended their minds till they cracked, without any like result. It would be idle either to affirm or to deny that the last half-century has produced men of science of the caliber of Newton. It is sufficient that it can show a few capacities of the first rank, competent not only to deal profitably with the inheritance bequeathed by their scientific forefathers, but to pass on to their successors physical truths of a higher order than any yet reached by the human race. And if they have succeeded as Newton succeeded, it is because they have sought truth as he sought it, with no other object than the finding it.

* Fresnel, after a brilliant career of discovery in some of the most difficult regions of physico-mathematical science, died at thirty-nine years of age. The following passage of a letter from him to Young (written in November, 1824), quoted by Whewell, so aptly illustrates the spirit which animates the scientific inquirer that I may cite it:

"For a long time that sensibility, or that vanity, which people call love of glory, is much blunted in me. I labor much less to catch the suffrages of the public than to obtain an inward approval which has always been the mental reward of my efforts. Without doubt I have often wanted the spur of vanity to excite me to pursue my researches in moments of disgust and discouragement. But all the compliments which I have received from MM. Arago, De Laplace, or Biot, never gave me so much pleasure as the discovery of a theoretical truth or the confirmation of a calculation by experiment."

† "Mémorable exemple de l'impuissance des recherches collectives appliquées à la découverte des vérités nouvelles!" says one of the most distinguished of living French *savants*, of the corporate chemical work of the old Académie des Sciences. (See Berthelot, "Science et Philosophie," p. 201.)

CHANGES IN THE RELATIVE VALUES OF THE PRECIOUS METALS.

By Hon. DAVID A. WELLS, LL. D., D. C. L.

ECONOMIC DISTURBANCE SERIES, No. VI.

THE ECONOMIC DISTURBANCES RESULTING FROM RECENT CHANGES IN THE RELATIVE VALUES OF THE PRECIOUS METALS.—Notwithstanding the great attention that has been given to this subject in recent years—with its almost interminable resulting publications and public and private discussions—there is probably no other one economic or fiscal problem concerning which there is so little comprehension on the part of the general public, or so little agreement as to causes and results among those who have made it a matter of special investigation.* It is of the first importance, therefore, for the understanding of the past involved economic disturbances, that a clear and succinct statement of what has happened should be presented, and such a statement it is now proposed to attempt.

For many years prior to 1873 the bullion price of silver remained very nearly constant at from 60 to 61 pence per ounce on the London market, while the market ratio of gold to silver, or the ratio according to which gold and silver could be interchanged, was limited in London, from 1851 to 1872 inclusive, to a range of variation of from 1 to 15·19 (the minimum) in 1859 to 1 to 15·65 (the maximum) in 1872.†

In 1873 the new German Empire—recognizing the importance of having a monetary system better suited to her advanced industrial and commercial situation than that which she then possessed, and also the desirability of having a uniform coinage throughout the numerous small states that had come to be included under an Imperial Government—took advantage of the command of a large stock of gold, that had accrued through the payment by France of an enormous war indemnity,‡ to effect reform. An exceedingly miscellaneous system of coinage and currency—consisting of seventeen varieties of gold money; sixty-six different coins of silver, possessing full legal-tender powers and constituting (in 1870) 65·7 per cent of the entire circulation; forty-six kinds of notes issued by thirty-five different banks, besides state paper money of various kinds to the extent of 7·5 per cent of the cir-

* "It has been my experience, that about nine men out of ten, even of those who might be expected to have some definite views upon the subject, when asked their opinion upon the expediency or necessity of adopting a bimetallic monetary system, will reply, Oh, that is a very important question, but I do not pretend to understand it.' "—EDWARD ATKINSON, *British Association Proceedings, 1887.*

† Pixley and Abell's "Tables," London.

‡ The amount in gold which France paid to Germany directly was $54,000,000; but in addition there were French bills of exchange which gave Germany a title to gold in places like London, on which such bills were negotiated.

culation—was accordingly called in, and replaced by a new system of gold and silver coinage and paper currency. In this new system, gold was established as the sole monetary standard of the empire, unlimited of necessity in respect to legal-tender powers, while to silver was assigned the function of subsidiary service; and for the latter purpose an issue of silver coinage was provided, not to exceed in the aggregate 10 marks ($2.50) for each inhabitant of the empire (a comparatively low figure), with its legal-tender value limited to 20 marks ($5). An issue of new paper currency was also authorized, with a prohibition of the use of notes of a less denomination than 100 marks ($25), to be distributed according to population among the various states, and redeemable in the new imperial coinage. A proportion of the old silver coinage, which, having been supplanted by gold, was not needed for recoinage under the new system, was offered for sale in the open market as bullion, and the amount actually sold between 1873 and the end of May, 1879, when the sales were suspended, realized $141,784,948. Of this aggregate, $45,644,311 was sold between the years 1873 and 1876, and $96,140,627 between 1877 and 1879 inclusive.

Concurrently with this action of Germany the bullion price of silver began to decline, and this decline was undoubtedly further promoted by the subsequent action of the so-called "Latin Union"—comprising the four countries of Europe using the franc system, namely, France, Belgium, Italy, and Switzerland—which, fearing lest the silver liberated from use in Germany, and offered for sale, would flow in upon and flood their respective mints, to the entire exclusion of gold if the free coinage of silver was continued; first restricted (in 1874), and finally (in 1877–'78), owing to the continued decline in the value of silver, entirely suspended the coinage of silver five-franc pieces. The coinage of subsidiary silver, or silver of smaller denominations than five francs, was, however, permitted and continued.

In 1873, also, the Congress of the United States, in revising its coinage system, dropped from the list of silver coins authorized to be thereafter issued from its mint, the silver dollar of 412½ grains, although providing for the unlimited issue and coinage of silver in pieces of smaller denominations than the dollar; and mainly for the reason, that this particular silver coin was not then in circulation in the country, and indeed had not been for a period of more than twenty-five years.

The extent of the decline in the price of bar-silver per standard ounce, in pence, upon the London market since 1873, is shown by the following exhibit of annual average quotations:

1873, 59¼*d.*	1879, 51⅛*d.*
1874, 58 $\frac{15}{16}$*d.*	1883, 50⅜*d.*
1875, 56⅞*d.*	1885, 48 $\frac{9}{16}$*d.*
1876, 52¾*d.*	1886, 45⅜*d.*

In July, 1886, the price of silver temporarily fell to 42½*d.* per ounce—the lowest price ever known in history—but reacted in October of

the same year to 45⅛*d.* From January to September, 1887, the average price was 46·8*d.*, declining to 44⅛*d.* in October.

During the early years of the decline of silver, the opinion was extensively entertained, that it was primarily and mainly occasioned by the new supply to the world's market, consequent upon the sales of silver by Germany,* and this opinion found so much of favor with leading German bankers, that it is understood that Germany suspended her sales of silver in 1879 in accordance with their advice, and with the expectation that a partial or entire recovery of price would thereby ensue. But no such result, as is well known, followed the suspension of sales thus recommended. How little, moreover, there was of foundation for this opinion, will appear from the following circumstances:

The aggregate silver product of the world during the years (1873–'79), when Germany was selling her discarded coinage, was $581,800,000, or more than four times the amount of the sales ($141,781,000) which Germany actually effected. Again, during the same period of years when Germany was increasing the world's supply of silver, through her sales, to the extent of $141,781,000, the United States drew upon and reduced this same supply by increasing her dollar and subsidiary coinage to the amount of $111,307,187.† Surely the world's status of silver during these years must have been one of extraordinarily unstable equilibrium from antecedent causes, threatening serious fluctuations in price even in the absence of anything abnormal, if the addition of so small a net product during six years as $30,473,000 to the current market supply of silver could depress the average bullion price of the world's mass of this metal from 59¼ to 51¼ pence per ounce, or over thirteen per cent.

That the term "unstable equilibrium" is truly expressive of the real status of silver in 1873 would further appear from the following evidence: There was a well-recognized movement in France against silver and in favor of gold from 1853 to 1865, and its influence would probably have shown itself in a fall in value of silver, had it not have been for the cotton-famine consequent on the American war, which occasioned extraordinary shipments of silver to India, and so counter-

* The amount of silver (old coin) which Germany up to 1880 was able to sell, as the result of her policy of displacing silver by gold, has been estimated at $270,000,000. Of this amount $141,781,000 had been sold up to May, 1879, when the sales were suspended; and since then, it is understood, that only a few additional millions have been marketed, i. e., to Egypt. In addition, Denmark, Sweden, and Norway, which followed the lead of Germany, and changed their silver circulation to gold, have since thrown upon the market about $9,000,000 of silver. (See LAUGHLIN'S *History of Bimetallism in the United States*, pp. 141–145.)

† During the twenty years from 1853 to 1873, the aggregate silver coinage of the United States was $57,137,000, or an average of only $2,856,000 per annum, and of this aggregate but $5,538,948 was in the form of silver dollars. From 1874 to 1879, inclusive, the silver coinage of the United States was 35,859,360 trade-dollars, 35,801,000 standard dollars, 22,899,785 halves, and 16,747,042 quarters and twenty-cent pieces; total, $111,307,187, or an average of $18,560,000 per annum.

acted any tendency then existing to a surplus in the European markets. In 1867 an International Monetary Conference at Paris voted almost unanimously in favor of the adoption of a single gold standard by the chief commercial nations. As far back as 1860, the late Professor Cairnes, who is recognized as a far-seeing economist, ventured the prediction that silver was in the process of depreciation. Another influence tending to powerfully affect the status of silver in 1873 was due to the circumstance that, subsequent to 1868–'69, the India Council greatly increased the sale of their bills (i. e., drawn on India and payable in silver) on the London market, and so virtually increased the stock of marketable silver at that point to the extent of from $20,000,000 to $30,000,000 annually, in excess of what it had been for the years immediately previous.*

The German "sales" theory being thus untenable, another hypothesis has found wide acceptation—namely, that, notwithstanding any absolute or comparative increase in the supply of silver during recent years, its decline in price and the economic disturbances which are alleged to have followed, would not have occurred, had it not been for the "demonetization" or the general discrediting of this metal for use as money; which has been contingent on the adoption of gold as the sole monetary standard and as a larger instrumentality of exchange by several of the most important commercial countries—notably Germany and the United States; or, as a leading American statesman has expressed it, "but for the striking down of one half of the world's coinage," and "compelling gold to do the work of both gold and silver." But here, also, the evidence in confirmation of this hypothesis is exceedingly unsatisfactory or wholly lacking. If by demonetization is meant that there has been less of silver in use and circulation as money, absolutely or comparatively, throughout the world since 1873 than formerly; or that the people of any country have been inhibited to their disadvantage in its use; or that, in consequence of any restrictions on its use for coinage, production and trade have decreased, and the prices of commodities and wages have fallen—the assumptions are not warranted, and the term demonetization is meaningless. The world's average annual production of silver since 1873 has been greater than ever before. Between 1873 and 1887, inclusive, the aggregate

* The Government of India is under obligation to pay annually in England certain fixed charges in gold, the same being in the nature of reimbursements—principal or interest—to England for loans on account of public works in India, receipts from railroads belonging to the British Government, pensions chargeable to India, etc. India being exclusively a silver-using country, pays its taxes and railroad freights and fares, etc., exclusively in silver; and in liquidation of its foreign monetary obligations, silver is remitted to London in the form of bills (exchange) payable in the silver currency of India, namely, rupees, which are drawn by the India Council, or the Government of India residing in London. It must be obvious that to just the amount of such council bills or drafts as are sold in London, to just that same extent the exportation of silver for business purposes is supplemented or made unnecessary.

product—measured in dollars of 412½ grains each—has been in excess of $1,250,000,000, and most of it has passed into circulation as coin, or lies piled up in national depositories awaiting any popular demand for its employment;* and the greater number of the daily transactions of trade continue to be settled by the use of silver, just as formerly. "If you take," says Mr. Robert Giffen, in his testimony before the British Gold and Silver Commission, 1886, "the fifteen years from 1870, and compare them with the fifteen years before, you will find that the practical diminution for the demand for silver in France, and I suppose it has been the same in other Latin countries, has not been sensible at all." The continually increasing importation of silver into India, China, Burmah, and Japan is conclusive also as to the absence of any restrictions on the use of this metal for coinage purposes in these countries.† In short, all that is now claimed by one of the most distinguished economists who inclines to the view that the monetary use of silver has been artificially restricted, is that its employment for coinage might possibly have been greater if it had not been for the action of the Latin Convention countries.‡ But it is obvious that this opinion must be necessarily a matter of conjecture.

Again, the world has never made so great a progress in respect to all things material in any equal number of years as it has during those which have elapsed since silver began to decline in price in 1873. Never before in any corresponding period of time has labor been so productive; never has the volume of trade and commerce been greater; never has wealth more rapidly accumulated; never has there been so much abundance for distribution on so favorable terms to the masses; never, finally, would an ounce of silver exchange for so much of sugar, wheat, wool, iron, copper, coal, or of most other commodities, as at present. If the fall in the price of all desirable commodities has been an evil, as not a few seem to believe, it can not be conclusively proved, in respect to even one article, that any such

* The number of standard silver dollars in the United States in 1879, the year of the redemption of specie payments by the Federal Government, was reported at 35,801,000. The number coined between March, 1878, and August 31, 1887, was 270,200,117, of which 65,336,063 remained at the latter date in the Federal Treasury, after deducting the silver held for the redemption of silver certificates in circulation. The Mint estimate of the silver coin in circulation in the United States in 1886 (dollars and subsidiary) was $308,784,223.

† During the fifteen years from 1855 to 1870 the annual demand of India for silver was very nearly £10,000,000. This period embraced the cotton-famine. From 1872 to 1875, just before the drop in silver, the amount that India annually received was £3,000,000. From 1875 to 1880 it was £7,000,000; from 1880–'85, £6,000,000; and for 1885–'86, nearly £12,000,000.

‡ "The suspension of the free coinage of silver by the Latin Union operated not to diminish the actual employment for silver as compared with what had been in existence before 1872, but a possible employment which might have come into existence if the law had not changed."—(See testimony of Mr. Robert Giffen, British Gold and Silver Commission, First Report, p. 28)

fall has been extensively due to any decline in the value of silver or any appreciation of gold.

On the other hand, a more rational explanation of the decline since 1873 in the value of silver, and one which the logic of subsequent events is substantiating, would appear to be as follows: Since 1860 the annual product of silver has been rapidly increasing—i. e., from $40,800,000 in 1860 to $51,950,000 in 1865; $61,050,000 in 1871; $80,500,000 in 1875; $96,000,000 in 1880; $124,900,000 in 1885.* The aggregate product from 1860 to 1873, inclusive, was $990,000,000. Previous to 1871–'72 neither France nor the Latin Convention states of Europe had been large consumers of silver. In fact, from about 1850 to 1864, France, instead of being a consumer, was really a seller of silver, and during that period disposed of about £75,000,000 ($375,000,000). After 1864 the tide turned, and France began to take back silver, but up to 1873–'74 her imports had by no means balanced her previous exports. M. Victor Bonnet, writing in 1873 ("Revue des Deux Mondes"), after the greater part of the French indemnity had been paid, estimated the quantity of specie remaining in the possession of the French people at 6,000,000,000 francs ($1,200,000,000). China, also, which previous to 1864 had been a silver-importing country, after 1864 and until up to about the time of the drop in silver, became a silver-exporting country.† From 1853 to 1873, inclusive, the United States furthermore coined but very little silver, and during this whole period drew on the world's supply of silver for coinage purposes to an extent (measured in dollars) of only $57,137,000; while, during her long period of suspension of specie payments, subsequent to 1861, her stock of silver coin entirely disappeared from circulation, and in great part was doubtless added to the supply of other countries.

Under such circumstances, which were perfectly well known to the custodians and dealers in silver everywhere, Germany entered the world's market as a seller of silver. The amount offered at first was absolutely very small and comparatively insignificant, but it nevertheless probably constituted a supply in excess of any current demand. As the states of Europe and the United States could not at once increase their consumption and import of the products of Asia, Africa, and South America, and so increase their sales (exports) of silver, and, as the price which the surplus of any commodity forced for sale will command determines the price of the whole stock of such commodity, the price of the whole stock of silver bullion naturally began to decline. The general policy of Germany respecting the use of silver for coinage, which was subsequently favored and adopted by Sweden, Norway, Denmark, and Holland, with the concurrent suspen-

* The average annual production of silver, according to M. Soetbeer, was $24,334,750 from 1811–'20; $20,725,000, 1820–'31; $26,840,000, 1831–'40; $35,118,000, 1841–'50.

† Testimony of Mr. Robert Giffen, First Report of the British Gold and Silver Commission, p. 29.

sion by the states of the Latin Union of the free coinage of the silver five-franc pieces, also unquestionably favored and intensified the decline in the price of silver thus inaugurated, by creating an apprehension (or scare) among the bullion-dealers as to what might further happen.

The continued decline in the value of silver in more recent years—i. e., from an annual average of 51¼*d.* in 1879 to 45⅝*d.* in 1886—may also be rationally referred to a continuance of the same influences. The annual product of silver has continued to increase—i. e., from $96,000,000 in 1879 to $124,900,000 in 1886, or $762,000,000 in the aggregate for this period. No one knows what is to be the product of silver in the future; but it is reasonable to believe that, if the price of silver were to advance materially, its product would be largely augmented. Recent reports made under the auspices of the Mexican Secretary of the Interior, and published in the "Mexican Economist" (1886), claim that the cost of working the argentiferous lead-ores of Mexico, which "exist in prodigious abundance," has been greatly reduced within recent years, and that under a better system of taxation and with an adequate supply of capital the annual product of the silver-mines of Mexico could be quickly doubled and even trebled. Furthermore, an average decrease of at least thirty per cent in the prices of the commodities that represent the great bulk of the world's production and consumption (comparing the data of 1885–'86 with those of 1867–'77) has in itself been equivalent to largely or entirely supplementing any increased demand for the use of silver and gold as money, consequent upon any increase in the volume of the world's business during the same period. The constantly-increasing tendency of civilized countries to use less and less of coin in the transaction of business, and the continued invention and successful application of numerous and unprecedented devices for economizing the use of metallic money, must at the same time have been equivalent to a constant comparative increase in the supply of precious metals for coinage purposes. Still another factor exercising a disturbing influence on the price of silver, and preventing its price recovery, undoubtedly grows out of the fiscal relations of Great Britain with India. The regular annual sales at London of India Council bills—the character of which has been heretofore explained (see page 173)—are in the nature of forced sales of silver, and at present average about $45,000,000 per annum. How much effect these sales, at the point where the silver-bullion trade of the world centers, have had in depressing the market price of silver, is undetermined; but that it has not been unimportant can not well be doubted.

Attention is next asked to the character of the economic disturbances which have resulted from the change since 1873 in the relative values of gold and silver. Omitting from consideration the extreme views on this subject, in which silver seems to be regarded in the sense of a personality that has been unjustly and designedly "outlawed"

and deprived of some ancient prerogative, the disturbances in question are the same in character as have always accompanied the use of a depreciated, fluctuating currency, with this additional and novel peculiarity—namely, that while, heretofore, depreciation of currency has been due to the forced issue of redundant and irredeemable paper money or debased coin, and has been local in its influence, the present experience is due to a depreciation in the value of one of the precious metals with reference to the other, and extends to many countries in very different degrees. Let us particularize these disturbances, and see how serious or otherwise have been their resulting influence.

In the United States, all the evil which has thus far been experienced has been solely from apprehensions of evil in the future, which in turn have been occasioned by the circumstance that the United States, in harmony with her protective policy, buys from the owners of the (present) most productive and cheaply-worked silver-mines in the world, silver bullion for coinage to the value of $2,000,000 monthly, irrespective of any current demand or necessity for such coinage on the part of her own people. In the coinage system of Great Britain the function of silver remains as it has for a long period, almost as unimportant as that of copper. In Germany, "although the imperial mark is now everywhere recognized as the standard, all Germans, whether they live in Bavaria, Prussia, or Hanover, are able to sell their commodities with the consciousness that the 'marks' they receive in payment for them are good money, with the same purchasing power, whether paid out as silver thalers or as gold crowns."* Furthermore, at a meeting of the representatives of the various Chambers of Commerce in Germany, in March, 1887, seventy-one chambers to four voted against any change in the existing monetary policy of the Empire. In the other states of Europe, the currencies of which are on a specie-paying basis, the situation is substantially the same as in Germany.† In exclusively silver-using countries, like India and Mexico, the decline in the value of silver has not appreciably affected its purchasing power in respect to all domestic products and services; but the silver of such countries will not exchange for the same amount of gold as formerly, and it might be supposed that, owing to this change in

* Communication by a director of the Bank of England (Mr. H. H. Gibbs) to the "Der Kampf um die Währung," Berlin, April 30, 1886.

† "There are no indications of any change in the policy of the fiscal authorities of the several states visited by me (Great Britain, France, Germany, Belgium, and Holland) which warrant any expectation that the subject of a bimetallic treaty for a common legal tender, coupled with the free coinage of silver, will be seriously considered at the present time by them. . . .

"There is no indication that the subject of bimetallism has received any intelligent or serious consideration, outside of a small circle in each country named, as a probable or possible remedy for the existing causes of alleged depression in trade."—*Report to the President of the United States "On the Present Status of Bimetallism in Europe," October, 1887, by* EDWARD ATKINSON.

the relative value of the two metals, the silver of India, Mexico, and other like countries would purchase correspondingly less of the commodities of foreign countries which are produced and sold on a gold basis. But the people of such countries have not thus far been sensible of any losses to themselves thereby accruing, for the reason that the gold prices of such foreign commodities as they are in the habit of buying have declined in a greater ratio since 1873 than has the silver which constitutes their standard of prices—a condition of things which Don Francisco Bulnes, the distinguished Mexican economist, in a recent official report, has exemplified to his countrymen by the following felicitous illustration :

"Two merchants, named Mexico and Foreigner, exchange annually cotton shirtings for silver dollars : Mexico delivers $100, and receives from Foreigner one hundred pieces of cotton shirting. By the depreciation of silver, it results that Foreigner only wishes to accept the Mexican dollar for eighty-six cents for each one, but gives in exchange each piece of cotton shirting for sixty-six cents. Which of the two will be the loser?" Nevertheless, if silver had maintained its former relative value to gold, the benefit accruing to silver-using nations from the decline in the prices of commodities through improvements in their production and distribution might have been greater; but, if so, the loss does not appear to have been made by them a cause of complaint.

All the evidence seems to indicate that the economic disturbances contingent on the decline in the value of silver, apart from what have been due to the apprehension of evil (or scare), have thus far been almost exclusively confined to the trade or financial intercourse between the gold-standard and the silver-standard nations, or between the states of Western Europe and the United States, and the nations of the Eastern hemisphere and of Central and South America ; and that the manifestations of these disturbances have been greatest in England and Holland, where the foreign trade of the silver-using countries largely centers. And it seems further to be admitted that these disturbances have not resulted so much from a fall in the value of silver *per se* as from the uncertainties or fluctuations in its price, or, as commonly expressed, in the rates of exchange—an eminent merchant of Manchester, England, largely engaged in trade with India and the East, being reported as saying, at the last meeting of the British Association (September, 1887), that with the present excellent telegraph service, and a level (non-fluctuating) monetary basis, exchange in India would be as steady as in New York. In all this, there is, however, nothing unprecedented or in the nature of the unexpected ; nothing which the world has not heretofore repeatedly experienced. For it is to be remembered that fluctuations in exchange are the invariable accompaniment of trade with nations using a depreciated and fluctuating currency ; and that there is no good

reason for supposing that the disturbances which have characterized the trade of Europe with India and the East during recent years, from fluctuations in the price of silver, have been any different in kind than, or as great in degree as, those which characterized the trade of Europe with the United States from 1861 to 1879, or which characterize to-day the trade of the outside world with Russia, whose currency is depreciated and fluctuating. Moreover, the difficulties arising from the uncertainties of exchange, at least between England and India, appear to have been greatly exaggerated. Mr. Lord, a director of the Manchester (England) Chamber of Commerce, testified before the Commission on the Depression of Trade, in 1886, that, "so far as India was concerned, it is not necessary to run any risk at all," from the uncertainties of exchange. Mr. Bythell (representing the Bombay Chamber of Commerce) testified before the same commission: "He [Mr. Gibbs] says that commerce with India is paralyzed. I deny the assertion. There is no difficulty in negotiating any transaction for shipping goods to India, and in securing exchange." It is also beginning to be generally recognized that, owing to telegraph correspondence and rapid steam communication, the risk in transacting business between different countries, contingent on fluctuations in exchange, is being gradually eliminated, inasmuch as sales and purchases, or remittances, and all the incidents of exchange, freights, commission, etc., can be practically arranged between the operators at one and the same time.*

But whatever may have been the disturbances resulting from fluctuations in rates of exchange between Great Britain and the silver-using countries (of which India is the chief), contingent on the fluctuations in recent years in the price of silver, these disturbances do not appear to have had any effect up to 1884–'85 in checking the volume of British trade with Eastern nations, or in changing the relations of exports and imports that previously existed. Thus, from returns officially presented to the British Gold and Silver Commission, 1886, it was established that the trade of Great Britain with India since 1874 had relatively grown faster than with any foreign country, "except the United States and perhaps Holland." Assuming 100 to represent the trade between the two countries in 1874–'75, the imports from the United Kingdom into India rose from 100 to 154 in 1884–'85, and the exports from India to the United Kingdom from 100 to 149. Much also has been said respecting the serious injury which the export trade in cotton manufactures from England to India has sustained in recent years

* "If trade can go on profitably between countries having an inconvertible paper of a widely fluctuating kind and the rest of the world, *a fortiori*, it can go on between gold and silver countries. The exchange is a hindrance and obstacle, as many other things are hindrances and obstacles, but it is nothing more. . . . Such difficulties are the ordinary incidence of trade and life, and will be dealt with like other difficulties of a far more serious kind by those concerned."—*London Times, September 14, 1886.*

in consequence of the "dislocation" of the money of England's Indian customers. But the facts do not bear out such statements. Taking the number 100 as representing the condition of the cotton-fabric export trade of England with India in 1874, the numbers for 1876 were, respectively, 134 for quantity and 96 for value; and this change in value, as was testified to before the Gold and Silver Commission, has "occurred since 1883"; or was coincident with a recognized increase at that date in the manufacturing capacity of the cotton-factories of Europe and the United States, greatly in excess of any current market demand for consumption.*

In like manner the official returns also show that while India during recent years has largely increased her exports of domestic cotton fabrics —cloth and yarn—to China and Java, the exports of like products from England to these same countries from 1875 to 1884–'85—the period covering the greatest decline in the price of silver (or of the fall in exchange)—also continually increased; or for 1884 were 14 per cent in the case of piece goods, and 32 per cent in yarn, greater in the aggregate than they were in 1875. Since 1884–'85 the condition of the British export trade to China is reported to have been less favorable.

It might also seem that the Government of India, in selling its remittances in silver—India Council bills—to cover its liabilities in England, for a less price in gold than formerly, constantly experiences a loss; but, on the other hand, it is well established that the increase in the revenues of India, since the decline in silver began, owing to the increased prosperity of the country and the increased receipts of the government railways, fully counterbalances any loss they may have incurred in remitting silver against their gold liabilities.

Another pertinent example, and one not in any way connected with the trade of Europe or India, is afforded by the recent trade experiences of Mexico. This country has almost exclusively a silver currency; and the fluctuations in the price of silver since 1873—Mexican exchange having varied in New York in recent years from 114 to 140 †—would seem necessarily to have been a disturbing factor of no little importance in the trade between the United States and Mexico. But

* In 1870 the British export of cotton piece-goods to India was returned at 923,000,000 yards, representing 28·4 per cent of the entire trade of the United Kingdom with India. In 1884 the export of these same goods was 1,791,000,000 yards, or 40·6 per cent of the entire trade. In respect to cotton yarns the British exports to India for 1870 were 31,000,000 pounds, or 16·5 per cent of the total exports; and in 1884, 49,000,000 pounds, or 18·1 per cent of the total exports. The bulk of the trade of Great Britain is with gold-using countries; and yet, while the trade of India with Great Britain was 8·3 per cent of the whole trade of the kingdom in 1870, it constituted in 1883 as much as 9·9 per cent of the whole trade.—*Testimony before the Gold and Silver Commission of* Mr. HENRY WATERFIELD, *Financial Secretary of the India Office, London.* (See First Report of Commission, pp. 122, 123.)

† That is, one hundred and forty Mexican dollars to one hundred dollars of the United States gold standard.

the official statistics of the trade between the two countries since 1873 (notoriously undervalued) fail to show that any serious interruption has occurred; the domestic exports from the United States to Mexico having increased from $3,941,000 in 1873, to $11,089,000 in 1884; while the exports from Mexico to the United States during the same period increased from $4,276,000 to $9,016,000.

In recent years there has been a notable increase in the cotton-manufacturing industry of India—i. e., from fifteen factories, with 450,156 spindles and 4,972 looms in 1873, to seventy factories, with 1,698,000 spindles and 14,635 looms in 1884; and the cause of this increase, which is enabling India to compete (as never before) with Lancashire (England) in supplying cotton yarn and fabrics to the Indian and other Eastern markets, and to the alleged serious detriment of English interests, is popularly believed and asserted to have been occasioned mainly by the decline and fluctuations in the price of silver. The cross-examination of experts in the Anglo-Indian trade by the British Gold and Silver Commission conclusively showed, however, that the prime cause of the increasing ability of India cotton-manufacturers to compete successfully with those of England is to be found in the advantages which accrue to the former from the lower wages and longer factory-hours* of their employés. But the existing differences as respects the condition of labor in England and India have existed from time immemorial; and the only novelty of the present situation is, that now India, with railroads and factories, and the advantage of cheap ocean freights, is emancipating herself from chronic sluggishness and beginning to participate in the world's progress; and under English auspices, and largely with English capital, is, for the first time, extensively utilizing her cheap and abundant labor in connection with labor-saving machinery. And it is to be further noted that her progress in cotton manufacturing exhibited itself unmistakably some years before the commencement of the decline in silver; that the first shipment of cotton yarns from India to China, in competition with yarns of English make, was in 1866, and that between 1865 and 1873 the increase in the number of cotton spindles in India was in excess of 57 per cent.

The belief is also very general that the decline in silver has abnormally stimulated exports from silver-using countries, to the great detriment of the wheat-growers of the United States and Australia, who offer their surplus in competition with the surplus of India upon the European market. Nothing is easier than to get into a state of mental confusion in respect to this matter, and, in fact, there seems to be no assignable limit to the multiplication of words upon it.

* The hours of labor in the factories of Bombay are reported at eighty per week in comparison with fifty-six per week in England. The wages of skilled labor in Bombay, in common with the wages of similar labor in countries of the western hemisphere, are reported to have materially advanced in the recent years.

But, in forming an opinion concerning it, it is important to steadily keep in mind the fact, that international trade is trade in commodities, and not in money; and that the precious metals come in only for the settlement of balances. In fact, all such exchanges are, to within a very minute fraction, the result of an organized and elaborate system of barter, and the principle of barter prevails in them, and determines to a great extent the methods employed. The trade between England and India is an exchange of service for service. Its character would not be altered if India should adopt the gold standard to-morrow, or if she should, like Russia, adopt an irredeemable paper currency, or, like China, buy and sell by weight instead of tale. Will India give more wheat for a given amount of cloth because she uses silver instead of gold in her internal trade? Will England give less of cloth for a given amount of wheat because she keeps her accounts in pounds, shillings, and pence instead of in rupees? Unless all the postulates of political economy are false—unless we are entirely mistaken in supposing that men in their individual capacity, and hence in their aggregate capacity as nations, are seeking the most satisfaction with the least labor, we must assume that India, England, and America produce and sell their goods to one another for the most they can get in other goods, regardless of the kind of money that their neighbors use or that they themselves use. A silver currency does not give any additional strength to a Hindoo ryot, nor does it increase the fertility of his soil, or add to the number of inches of his rainfall. Nor does a gold currency detract in any way from the capability and resources of his rival, the American farmer. Nor does the difference in their respective currencies affect the judgment of the buyer of wheat in Liverpool. Is any single factor in the elements of production and transportation, by which alone the terms of competition are settled, changed by the local currencies of the several countries, or the mutations thereof? Surely no mutations were ever more sudden or violent than those of the currency of the United States during the late war. They were not without their effects; but the effects were not of a kind to change the terms of competition in international trade.

It may be that the Indian wheat-grower has been enabled by the decline in silver to get labor for less wages than before, and has thus gained an advantage over his competitors in America and Australia; but the evidence is all to the effect that wages generally in India in recent years have advanced and not declined. But the terms of international competition are not altered by any division of the joint product of labor and capital in one of the competing countries. The person that has the most of a grievance growing out of the present state of the wheat-trade is the American farmer, who is restricted from buying in the same market in which he sells his surplus wheat to as good advantage as his competitors; but this is not due to any change in the value of silver, but to the fiscal policy of his own Government.

The whole subject of the disturbing influence of the decline in the value of silver on the trade between gold and silver using countries is complicated and difficult of analysis, and the opinions of persons practically interested in such trade are not harmonious; but it is difficult to see how one can investigate the subject, with the light of the experience which the years that have elapsed since 1873 has contributed, without coming to the conclusion that the seriousness of the disturbances has been greatly exaggerated, and that the expediency of attempting to provide remedies by legislation for such as may be acknowledged to exist—if legislation were practical—is very doubtful.*

One feature contingent on the fall in the value of silver, which appears to be regarded in England somewhat in the light of a popular grievance, is the decline in the value of the pensions, or "half" pay allowances which have been given by the Indian Government to their retiring officials for good and extended service. These pensions are granted in India, and are payable there in the current money of the country—i. e., the silver rupee—and, before the decline in silver, had an equal purchasing power with gold; and at the present time, so far as these pensions are spent in India, no loss occurs, because the purchasing power of silver in that country has not fallen materially. But, on the other hand, if the rupees are remitted to England, and sold there at the price of bullion, or if, what amounts to the same thing, the remittance is effected by the purchase of a bill of gold exchange on England, the loss in English money to the pension or half-pay recipient residing in England is considerable, and has been estimated to average about 25 per cent. At the same time, it is to be remembered that there has been no loss, but rather a gain, in the present purchasing power of silver, as compared with its purchasing power at the time when the pensions or half-pay in question were granted.

* In connection with this subject, the following extract from the record of the examination of Mr. H. Waterfield, Financial Secretary of the India Office, London, before the British Trade and Silver Commission (February, 1887), will be read with interest:

Question (Sir T. Farrer). "So that, while India has been doing much more, Lancashire has been doing more than she did before?"

Answer. "Yes."

Q. "Then I will ask you, do the figures [submitted] justify the statement that the present state of things—that is, the fall in exchange—is causing the gradual transfer of the yarn-trade of China to India; that the exports from England have steadily declined since the fall of silver commenced, while those from India have enormously increased?"

A. "The increase of the imports from India may, indeed, be termed enormous; but it is not correct to say that the exports from England have steadily declined since the fall of silver commenced; and I think that the fall in exchange is not the cause of the improvement in the Indian trade."

Q. "At any rate, you would not see in these figures any reason for protecting Lancashire against India by a radical alteration of our currency system?"

A. "No; I should think it as objectionable as allowing any protection of India against Lancashire."

It is not alleged that the Indian Government has violated any contract or stipulation; but that they "have proved ungenerous employés."* Important, however, as this matter doubtless is to those especially interested, it is one in which the world at large can not be expected to take much interest.

In Holland the disturbances assumed to have been occasioned by the decline in the value of silver have attracted public attention to an even greater degree than in England. But even here the disturbances have been mainly restricted to the commercial and financial relations of Holland with her East Indian colonies, Java, Sumatra, and other islands, and have been specially occasioned by the extraordinary fall in recent years in the prices of the principal exports of these islands, namely sugar and coffee. But no commercial fact is capable of more complete demonstration than that the fall in the price of these great staples has been in no way contingent upon any change in the value of silver.†

Finally, the idea of disturbance in connection with the decline in the value of silver has been and is pre-eminently connected with an annunciation and belief in two propositions: First, that the almost universal decline in the prices of the world's staple commodities since 1873 has been occasioned by the fall in the price of silver; and, second, that a decline of prices is an evil. The first of these propositions rests upon an assumption which can not be verified by any conclusive evidence whatever; and, as for the second, if the fall of prices has been mainly due, as has been demonstrated, to natural and permanent causes, namely, the increased power of mankind in the work of production and distribution; then the result, by creating a greater abundance of all good things, and bringing a larger amount of the same within the reach of the masses for consumption and enjoyment, has been one of the greatest of blessings.

* It is curious to note that when the rules regulating the pensions of the Indian Civil Service were established in 1863, the Indian Government stipulated that the rupee should not count for more than two shillings, which had been about its equivalent in sterling from time immemorial, even if at any time exchange on England rose to a higher point (as it actually did at one time, in 1861); but, not expecting that the rupee would ever fall in value to any great extent below 2s., or below that par of exchange, they omitted to provide against it.

† "During the last five years Java has been subject to the most fearful natural calamities. They have had a cattle-plague which destroyed almost the whole cattle in parts of the island; they have had cholera; they have had earthquakes of an unprecedented character, and they have had further an extraordinary fall in the values of their principal exports, which are sugar and coffee, owing, in the first place, to the competition of beet-root sugar in Europe; and, in the second place, to the fact that South America has been able to export coffee more favorably than Java; and to this extent we can trace a loss of £5,000,000 annually in these two articles. That has been the result in the last five years of natural causes, without any question of currency at all."—*Testimony of* Mr. PAUL F. TIDMAN, *East India merchant. First Report of the British Gold and Silver Commission, p. 142.*

Any discussion of the economic disturbances resulting from changes in the relative values of the precious metals, would be incomplete, that failed to point out how the events that originated the so-called "bimetallic" controversy were the natural outcome of the revolutionary changes in the methods and production and distribution that have occurred in recent years in all countries in proportion to their advance in civilization.

It is not easy to imagine that any person of ordinary intelligence can seriously believe, that the enactment of laws looking to the recognition of gold as the single standard of value, thereby effecting what is called the demonetization of silver, could ever have resulted from mere whim or caprice, or with a view of occasioning either domestic or international economic disturbance. There was a time when nations, with the expectation of receiving benefit, did adopt policies and enact laws with the undisguised and sole intent of injuring the industry and commerce of neighbors with whom they were at peace; but happily such days have long past. And the inference is, therefore, fully warranted that whatever steps have been taken, which have resulted in any territorial restriction of the use of silver as money, have been in consequence of a belief by the parties—nations—thus acting, that such a policy was called for by change in the economic condition of their affairs, and was likely to be to them productive of benefit. And the answer to the pertinent question as to what *benefit*, is simply, that which might be expected to accrue from the using of the best rather than an inferior tool; of a money instrumentality adapted to new, rather than to old conditions of production and distribution.

One needs but to stand for a brief time at the marts of trade in countries of varied degrees of civilization, to quickly recognize and understand, that the kind of money a country will have and use, depends upon and will vary with, the extent and variety of its productions, the price of its labor, and the rapidity and magnitude of its exchanges; and investigation will further inform him that when mankind, savage, semi-civilized, civilized, or enlightened, find out by experimentation what metal or other instrumentality is best adapted to their wants as a medium of exchange, that metal or instrumentality they will employ; and that statute law can do little more than recognize and confirm the fact. In truth, legislation in respect to money, as is the case in respect to other things, never originates any new idea; "but merely enacts that that which has been found beneficial or prejudicial in many cases, shall be used, limited, or prohibited in all similar cases within its jurisdiction." Thus, in all countries where prices are low, wages small, transactions limited, and exchanges sluggish, nothing more valuable can be used as money for effecting the great bulk of the exchanges, than copper; and in countries like Mexico and China, even the copper coin corresponding to the American "cent," the English "half-penny," and the French "sou" is often so disproportionate in

point of value to the wants of retail trade, that in the former country it is made more useful by being halved and quartered, and in the latter is replaced with some even cheaper metal, as iron, or spelter. The wages in all such countries do not in general exceed twenty to twenty-five cents a day, and the sum of such wages, when represented in money, must be capable of division into as many parts in order to be exchanged for the many daily necessities of an individual or a family. But with wages at twenty-five cents per day, the use of coined gold would obviously be impracticable. The equivalent of a day's labor in gold would be too small to be conveniently handled; the equivalent of an hour's labor would be smaller than a pin's head. And in a lesser degree would be the inconvenience of using coined silver for effecting the division of similar small wages.*

In countries of higher civilization, but still of comparatively low prices and limited exchanges (and these last mainly internal or domestic), silver naturally takes the place of copper as the coin medium of exchange and as the standard of value; and as more than a thousand million people are the inhabitants of such countries, silver, reckoning transactions by number and probably also by amount, is to-day the principal money metal of the world.

On the other hand, in countries of high wages, rapid financial transactions, and extensive foreign commercial relations, the natural tendencies are altogether different, and favor the more extensive use of gold for money, without at the same time displacing from their legitimate monetary spheres either copper or silver.

The metal coinage system of the world is not therefore "mono-

* In many of the sugar-producing islands of the West Indies, the greatest number of the separate retail purchases at the established stores do not exceed from two to three cents in value. In the Island of Trinidad, probably 75 per cent of an annual importation of about 22,000,000 pounds of breadstuffs (110,000 barrels) pass into the ownership of the laboring-classes (whose average annual consumption is estimated at 31 pounds per head), through purchases for cash of quantities rarely exceeding a pound at any one time.

Corea, a country which until recently has been almost unknown to the civilized world, affords another striking illustration of the principle that the kind of money a people will have and use, if left free to choose, will be determined by the nature of their exchanges, through what may be termed a natural process of evolution, and not by artificial arrangements. Thus, Corea has been proved to be a very poor country; raising little more of any one product than will suffice for home consumption; and with a very restricted internal trade, owing to small production and the lack of facilities for personal intercommunication and product distribution. To a majority of her people a monthly income equivalent to two or three dollars, is represented to be sufficient to meet all their necessities. Yet even under these unfavorable and limited conditions of exchange, money has been found a necessity; and has come into use in Corea, in some unknown manner, in the shape of small metallic coinage—nominally copper, but really a sort of spelter-piece —500 to the dollar. With the opening of the ports of the country, a demand for certain foreign products has been created; and these, when obtained in exchange for hides and gold-dust, are sold to the people in quantities so small, that only coins of the value and character mentioned can be conveniently used as media of exchange—kerosene, for example, being sold by the half-gill, and matches in bunches of a dozen.

metallic," nor "bi-metallic," but tri-metallic; and the three metals in the form of coin, have been used concurrently throughout the world ever since the historic period, and in all probability will always continue to be so used; because by no other system that has yet been devised can the varying requirements of trade in respect to instrumentalities of exchange and measures of value be so perfectly satisfied. And the only change in this situation of monetary affairs has been, that gradually and by a process of evolution as natural and inevitable as any occurring in the animal or vegetable kingdom, gold has come to be recognized and demanded as never before in all countries of high civilization, as the best instrumentality for measuring values and effecting exchanges. It has become, in the first place, the money of account in the commercial world and of all international trade; and any country that proposes to find a foreign market for the surplus products of its labor must employ the very best machinery of trade —railroads, steamships, telegraphs, or money—if it does not propose to place itself at a disadvantage.

In respect to portability, convenience for use, adaptation to domestic and foreign business alike, the balance of advantage for all transactions, above $25 or £5, is also largely on the side of gold; as will be evident when it is remembered that it required, even before its depreciation, sixteen times more time to count silver in any considerable quantity than an equal value of gold; sixteen times more strength to handle it; sixteen times more packages, casks, or capacity to hold it, and sixteen times more expense to transport it. In other words, in this saving age, when the possibility of extensive business transactions is turning on profits reckoned not in cents but in fractions of cents per yard, per pound, or per bushel, to use silver for large transactions in the place of gold, is a misapplication of at least fifteen sixteenths of a given unit of effort, time, expense, and capacity, when one sixteenth would accomplish the same result.

Another factor which has without doubt powerfully influenced public opinion in countries of large and active domestic and foreign trade in favor of gold as the sole monetary standard in preference to silver, has been the advantage which gold seems to possess over silver in the element of stability of cost of production. The amount of labor involved in the mining or washing for gold has remained nearly constant for ages; while in the case of silver not only are new deposits of great richness continually being discovered, but many old mines hitherto unworked and unprofitable by reason of inaccessibility, or by the character of their ores, have been reopened and rendered profitable by improved facilities for transportation and cheaper processes of reduction.

Now, it is not asserted that it was exactly these considerations, as thus specified, that influenced Germany in 1873 to take advantage of the opportunity afforded by the payment of the French war in-

demnity* to adopt gold as the standard of her metallic coinage system—a policy which France would probably have adopted in 1870, had not war intervened—and that subsequently induced other countries to follow the example of Germany. But it can not be doubted that the motive in general which prompted the action of Germany in 1873, and which to-day enrolls so many of the best of the world's thinkers, financiers, and merchants, on the side of gold rather than that of silver in the pending and so-called bimetallic controversy, has been and is a conviction, that the movement in favor of a gold standard, by highly civilized and great commercial nations, is in consonance with the spirit of the age; that it was a necessity for the fullest development of production and traffic, and the same in kind which prompts to the substitution, regardless of cost, of new machinery for old, if even the minimum of gain can be thereby effected in the production and distribution of commodities. It may, however, be urged that granting all that may be claimed respecting the superiority of gold over silver as a standard of value and a medium of exchange, there is not a sufficiency of gold to supply the wants of all who may desire to avail themselves of its use for such purposes; and therefore, any attempt to effect innovations in former monetary conditions would be impolitic because likely to be generally injurious. But this would not be considered as an argument of any weight if pleaded in opposition to the whole or partial disuse of any other form of tool or machine in order that some better tool or machine might be substituted. That in such a case there would be an advantage to those who could afford to have and use the new, and a corresponding disadvantage to those who could not, may be admitted; but what would be the future of the world's progress, if the use of all improvements was to be delayed until all to whom such use would be advantageous could start on terms of equality?

If, therefore, the above premises are correct; if certain of the leading states of the world have given a preference to gold over silver in their trade, and have selected a single in place of a former double standard of value—not by reason of the adoption of any abstract theory or desire for experimentation, but rather through a determination to put themselves in accord with the new conditions of production and distribution that have been the outcome of inventions and discoveries during the last quarter of a century—then the inference is warranted, that all attempts to enforce, through any international conference or agreement, any different policy or practice, would be as futile as to attempt to displace through legislation railroads by stage coaches and steamships by sailing-vessels.

* "It was from this source that Germany proposed to help herself before it was too late, and thereby array herself in the rank of commercial states which, having large transactions, chose gold, not merely as the most stable in value of the two metals, but as the best medium of exchange for large payments."—Professor LAUGHLIN, *History of Bimetallism in the United States, p. 135.*

AMERICAN CINQUE-FOILS.

By GRANT ALLEN.

YOUR American cinque-foils are to me a deeply interesting set of plants. Excuse, I beg of you, dear Mr. Reader, this abrupt beginning. I love a *causerie:* I love to button-hole my audience, as it were, and, sitting down with it mentally on a bowlder in the meadow, to discuss the matter in hand with it *tête-à-tête*, as if we two were old friends, which I trust, after all, may be really the truth with the public of "The Popular Science Monthly" on the present occasion. For, indeed, a recent visit to America has made me realize you all far better than I ever did before; it has made me feel your individuality as I never hitherto felt it; and it has also renewed with me the acquaintance of many dear old floral favorites whose faces I had not seen in earnest for many a long and weary year. Among them, the cinque-foils or potentillas are, it is true, but a feeble folk; very different from the glorious orange lilies, and trilliums, and Solomon's-seals, whose bulbs and tubers I have brought home with me to beautify a little out-of-the-way Surrey garden; but still in their own humble fashion most interesting plants, from the implications as to their past history and transformations legibly written by the hand of Nature upon their very faces. I propose, therefore (having got you now fairly button-holed), to discourse somewhat concerning the American potentillas themselves, as well as concerning certain of their near and dear relations not included in the same genus by the artificial and unwise arrangements of our existing botany.

The first potentilla I found in America was by chance the very one that ought naturally to head the tribe in any systematic work, because it is the one which more than any other seems to preserve in the greatest simplicity the original traits of the prime ancestor. And when we consider that from this ancestor are also descended (in all likelihood) the plum, the peach, the cherry, the almond, the apple, the pear, the strawberry, the raspberry, the rose, and the hawthorn, it must immediately be apparent to the meanest understanding that the plant in question deserves the greatest consideration at our hands as the founder of a large and important family. Nevertheless, this rather scrubby weed (*Potentilla Norwegica*) with its yellow flowers and hairy stem, much resembles the founders of many other distinguished families in being personally mean, sordid, and inconspicuous. But in spite of its meanness, the Norway potentilla shows many signs of its high respectability as the representative of the elder branch of the family in the direct line. To begin with, its blossoms are a shabby yellow; and shabby yellow I take to have been the original color in every instance of the earliest petals of insect-fertilized flowers. Then, again, it is an annual

weed, and herbaceous annuals were doubtless the earliest form of all vegetation all the world over. Once more, the leaves are divided into three leaflets; and this type I take from its frequent recurrence not only among the potentillas themselves, but in the strawberries, the lady's-mantle, the simpler brambles, and many other species as well, to have been the original type of foliage for the entire rose family. Finally, certain minute technical characters in the stipules and the styles, with which I need not trouble you at the present moment, lead to the conviction that we have here to deal to some extent with a fair representative of the old ancestral potentilla form.

The Norway potentilla, however, is distinctly weedy—that is to say, it is one of those unpleasant, dusty-looking plants which loiter about on the precincts of the road-sides and in the waste purlieus of human cultivation. It attests its weediness by its bristly hairs, intended doubtless to repel insects and to make it unpalatable to cattle and horses. As its name implies, it is an Old-World form as well as a native-born American citizen; it is, in fact, a member of that ancient circumpolar pre-glacial flora which was driven down from the once mild and genial Arctic regions by the vast ice-sheet of the Glacial epoch to occupy the plain-lands of either hemisphere in these our chilly and degenerate modern summers. In Europe, however, it remains distinctly a more northern type than with you in America, where it spreads as far south as the Virginia hills.

On the Alpine tops of the White Mountains I was lucky enough to light upon another member of the potentilla group, not far removed in essentials from the Norwegian weed, but infinitely prettier, more delicate, and in a word less weedy all round. This is the plant which Asa Gray identifies with our European *Potentilla frigida* of the Swiss Alps; and I, who have a pious horror of unnecessary splitting and renaming and tinkering, have not the slightest objection to the identification in any way. But it is worth while to notice, what I often observed of almost every American species said to be identical with those of Europe, that the two plants are not absolutely the same: the time that has elapsed since the Great Ice age effectually severed the two continents has sufficed to produce distinct differences in nearly every kind of plant or animal. The flowers in the American specimens are smaller than in the Swiss, and the stems when full-grown are far less hairy.

Potentilla frigida exhibits all the common peculiarities of high Alpine or Arctic plants. It is a dwarf form, not one fifth the size of the Norway species; it is tufted thickly on its low stems, and it has that matted, close, creeping habit which I have already pointed out in this "Monthly" as the distinctive feature of the glacial flora. It sticks still to the three original leaflets, but its flowers, as is common in mountain types, are far larger and handsomer than those of the wayside weed with which we started our examination of the group. This Old-World

form, however, occurs nowhere in the United States except here on the topmost summits of the White Mountains, and even there it lingers on in scanty numbers, rapidly diminished by the growing warmth and the incursions of botanists. I took but a tiny spray for my own specimen, from a spot not far from Tuckerman's Ravine, and left the remainder of the plant I found there still growing. It would be a pity if these last survivors of the Glacial epoch, pushed up onto these chilly heights by the secular summer of our own day, should be exterminated by the hands of those who above all others are bound by natural piety to preserve and protect them.

All over Canada and the Northern States there grows a third and very common potentilla, the cinque-foil or "five-finger" of popular botany (*P. Canadensis*), a pretty, prostrate, creeping weed, with golden-yellow flowers springing close to the ground, and five leaflets instead of three to each leaf. Ever since the days of Linnæus this plant has been considered distinct from the common European cinque-foil (*P. reptans*), and the differences are certainly sufficient to justify their division as separate species, as systematic botany goes nowadays. Nevertheless, it is quite clear that we have here merely to deal with the American descendants of the same old circumpolar plant. No European naturalist who saw the Canadian cinque-foil for the first time would ever take it for a distinct type; if he found it growing in an English meadow, he would certainly pass it by unnoticed as the familiar cinque-foil of our eastern hemisphere. The differences can only be observed when you look closely into the plant, and they are all of easy adaptive character. In fact, we have here just the same tendency as that which we noticed in the mountain species, only carried, perhaps, one step farther. In that instance, the differences were only sufficient for sytematic botanists to rank the plant as a mere variety; in this case they are sufficient to give it the dignity of a distinct species. But at bottom nobody knows what is a variety and what a species, and it is a mere matter of individual judgment whether a particular form should be regarded as one or the other. It varies "according to the taste and fancy of the speller." Oakes considered the White Mountain potentilla a distinct American species, different from the Alpine kind in Europe, and christened it, accordingly, *P. Robbinsiana*, after the first person who discovered it on these chilly hill-tops. Asa Gray regards it rather as a mere variety, though he hesitates as to whether it comes nearer to the *P. frigida* of the Alps, or to the dwarf form known as *P. minima* (itself a very ill-marked species). It is always so when you come to compare the plants or animals over a large area. However distinct they may seem in particular localities, they shade off into one another by such imperceptible degrees at distant points that the task of drawing hard-and-fast lines, so lightly undertaken by the systematic biologist, becomes at last absolutely impossible.

This very Canadian cinque-foil, for example, runs into two extreme

forms, which have each been considered by confirmed "splitters" as distinct species. The first (*P. sarmentosa*, of Muhlenberg) grows for the most part on very dry soil, and like most plants of arid situations runs largely to pronounced hairiness; for it is a general rule that water-haunting kinds are smooth and glabrous, while dry or desert types are intensely hirsute (the reason for this wide distinction, though well known, would carry us too far away, this morning, from our main subject). The second form, erected by Michaux into a separate species (*P. simplex*) but reduced to subordinate rank as a variety by Torrey and Gray, belongs to moister soil or to deep meadows, where the lush grass prevents evaporation; and this type grows less hairy and greener, and attains a larger and more luxuriant stature. The two forms differ also in other ways, strictly dependent upon their differences of locality. *Sarmentosa*, the dry type, creeps squat upon the ground, as if to avoid the sun, and sends out long, rooting runners in every direction after the fashion of the strawberry-vine; whereas, *simplex*, the moister kind, has ascending stems, which rise in competition among the grasses around them, seldom if ever creep, and never produce summer runners. Again, *sarmentosa* begins to blossom early, and ends early—April to July in the latitude of New York; while *simplex* comes and stops a month or so later at either end—May to September in the same district. In other words, the dry-type flowers early in spring on its basking banks, but retires from the scorching heat of your American summer; while the moist type begins later in its shady habitat, but is less affected by the droughts of August.

Curiously enough, our common European cinque-foil (*P. reptans*), the exact analogue of your American plant, and fellow-descendant of the self-same pre-glacial ancestor, has also two well-marked forms usually considered as distinct species, but merging into one another by imperceptible gradations. The parent-type (*reptans* proper) grows in rich pastures or meadows, and answers best to your variety *simplex*, though it sends out long, creeping stems which root every now and again at the nodes; it has five large petals to each blossom, and the flowers are identical with those of the Canadian cinque-foil. But on open moors, heaths, and dry places, we have a smaller, closer, and more creeping form, the tormentil (*P. tormentilla*); it is silky-hairy, like your own *sarmentosa*, and its upper leaves have often only three leaflets instead of five, thus reverting to the ancestral type of foliage, when the plant was rather a tre-foil than a cinque-foil. But oddest of all, the small flowers have only four petals, arranged like a Maltese cross; whereas all their congeners have their full complement of five, in accordance with the old central plan of the entire rose family. Still, the first flower of all on each stem, produced when the plant is in its vigorous youth, has occasionally five petals; a reversionary fact of great interest. The tormentil has also an intermediate variety of its

own (*Tormentilla reptans* of the hair-splitters), which sometimes creeps like the true cinque-foil, and frequently breaks out into five-petaled blossoms. Even Mr. Bentham, that minute and conservative botanist, admits that "intermediate forms" sometimes occur which can not probably be referred to either species.

And yet, though the tormentil and the cinque-foil are thus intimately connected with one another, by imperceptible gradations, so great is the love of petty distinctions in the human breast, that Linnæus actually erected this slight, four-petaled variety, not only into a distinct species, but even into a separate genus (*Tormentilla*).

Let us return, however, to our immediate subject, the American potentillas. The next species recognized by Asa Gray is the silvery cinque-foil (*P. argentea*), a pretty little plant, with small, bright-yellow flowers, confined, for the most part, to very dry, barren, or sandy spots, and with thin, wiry, almost woody stems. It is remarkable for the soft, white, silvery down, that clothes the under side of the five-leaved foliage. The use of this down I do not know, though I suspect it to be a protection from some caterpillar or other insect, which attacks leaves on their under surface. At any rate, it is an exaggeration of the usual downiness of dry-soil species. The silvery cinque-foil is common to Europe and America, and I do not notice any perceptible difference between my English and Canadian specimens. It seems, in fact, to be one of the very few plants which have not altered to any recognizable degree on either side of the Atlantic since the end of the great Glacial epoch. As a proof, however, of the narrow way in which this dry-soil species is restricted and limited to the very sandiest or most barren situations, I may mention that it grows on two spots, and two spots only, within reach of my own home here in Surrey, England. Both these spots are knolls of a peculiarly soft and friable sandstone, into which the rain sinks immediately; and they are the only two bits of that particular formation (a subdivision of the Folkestone sands) to be found anywhere in the neighborhood.

I was shown, at Kingston, Canada, a specimen of another more weedy potentilla (*P. paradoxa*), which has hardly, as yet, made good its place in the Eastern States, but which, nevertheless, possesses a certain interest for naturalists of the Atlantic shore, as a member of the flora by which before long they are almost sure to be overrun. The species belongs to the western half of the continent, but it is already well established as an immigrant along the banks of the Ohio and the Mississippi, and it has been observed near Oneida, and elsewhere on the shores of Lake Ontario. My own specimen was gathered on a common at Kingston, where it seemed to have established itself in full vigor. Now the interest of this species centers in the fact that until lately the weeds of the Eastern States and Canada were almost entirely of European origin; they were the cosmopolitan pests of civilization, which have followed agriculture from Western Asia along

the Mediterranean to the shores of the Atlantic, and, crossing the ocean with seed-corn and fodder crops, have clogged the steps of the intrusive white man through all his colonies and settlements elsewhere. These cosmopolitan weeds succeeded in America to the soil once covered by forest-trees, whose indigenous undergrowth could not stand the garish sunlight of the open clearings. But nowadays, the weedier types of the Western prairie-belt are moving eastward, as farms move west; and being accustomed by nature to open plains, they will probably, in many cases, succeed in establishing themselves side by side with the older plagues of the long-suffering farmer. *Potentilla paradoxa* is one of the first crop of these weedy immigrants, and its appearance already on the shores of Lake Ontario is the signal for its future advance in a formed phalanx against the tilled fields of New York and New England.

This Western immigrant departs widely in one respect from the type of all the potentillas we have yet considered, and that is in the arrangement of its five, seven, or nine leaflets. In the true cinquefoils, and all their like, the leaflets are arranged, as we say, palmately —that is to say, all start together, like the lobes of a horse-chestnut leaf, from one point. In the *P. paradoxa* they are arranged pinnately —that is to say, they start in opposite pairs or singly, from a common midrib, like the barbs of a feather or the leaflets of a locust-leaf. The same arrangement, a more convenient one for long leaves, reappears in *P. Pennsylvanica*, which (in spite of the name incorrectly bestowed upon it by Linnæus) is a Northwestern species. But as I have not seen this last-named plant in the living state, and as I do not like to write about what I have only examined in a dried-up herbarium (a bad habit of the old-fashioned, purely structural botanists), I will say no more at present about it.

On the rocky hills of the North and West there occurs in July a rather pretty, half-shrub-like potentilla (*P. arguta*), which presents several other interesting peculiarities. This plant has brownish, hairy stems, covered with a viscid, clammy exudation, something like that which covers the young branches and buds of the clammy rose acacia (*Robinia viscosa*). As I observed that insects are often caught in this clammy secretion, exactly as in the case of the common catchflies (*Silene noctiflora Virginica, regia*, etc.), I have not the least doubt that the potentilla eats and digests the creatures it entraps, in order to supply it with nitrogenous material for its own pollen, ovules, and seeds. This is the more probable, as the clamminess increases near the flower-buds and blossoms, and is scarcely at all noticeable near the base of the stem. How the potentilla digests its food I do not know, but long observation has fully convinced me that whenever a plant has viscid, glandular hairs or secretions upon its penduncles, pedicels, calyx, and flower-buds, it is invariably an insect-catcher, and an insect-eater too. The flowers are the part that require the

most nitrogenous food, and near the flowers the nitrogen-catchers are situated.

Another peculiarity of *P. arguta* lies in its flowers, which are clustered in large and conspicuous masses, and have petals that vary from pale yellow to primrose or almost white. This is a very interesting fact, because the native color of the potentillas is yellow; but the mountain species, and many other kinds, have varied to snow-white blossoms; and here we get a plant, as it were, in the intermediate or undecided stage between the two colors. Notice, too, that *P. arguta* is an herb of the rocky hill-sides, and therefore half-way toward becoming a mountain species.

Now, on the summit of Mount Willard, just above the Notch of the White Mountains, I found another very beautiful member of this pretty group, the three-toothed cinque-foil (*P. tridentata*). This is one of your most northerly and mountain-loving potentillas, unknown in Europe, inhabiting the coast of New England from Cape Cod northward, and the mountain-tops of the great chains, from the Alleghanies to the Maine ranges, as well as in Canada, Labrador, and the extreme north of the continent. The three-toothed cinque-foil carries a step farther the same characteristic, for its flowers are pure white, as so often happens with mountain blossoms. Just in the same way, while almost all lowland buttercups are golden yellow, some of the Alpine buttercups are white as milk, and among these very potentillas there are a few lovely snow-white mountain species in Europe and Asia. One beautiful kind that I gathered on the Maritime Alps at Mentone (*P. saxifraga*) has a blossom as delicately mountainous in type as the saxifrages themselves, from which it takes its scientific name.

Of course, I don't for a moment mean it to be understood that I think *P. tridentata* is directly derived from *P. arguta*, or that the latter species is now on its way to merge into the former. My Mount Willard plant has palmate leaves of only three leaflets, while the common *P. arguta* of the northern hill-sides has pinnate leaves of from three to nine cut-edged divisions; and in many other technical points they differ widely from one another. All I mean to suggest is merely that the yellowish-white *P. arguta* is now just passing through a stage which the ancestors of *P. tridentata* must have passed through long ago. On the whole, to put it briefly, the potentillas are a yellow lot; but a few advanced members of the race are white; and still fewer, like the ornamental *P. nepalensis* and *P. atropurpurea* of our gardens, are crimson, scarlet, or bright red. So far as I know, no potentilla is ever blue, which is the highest level of floral coloration.

The three-toothed cinque-foil has an almost shrubby and woody root-stock, and displays a tendency to assume the character of a true shrub. But its northern habitat and mountain manners keep it low and tufted, after the common fashion of upland vegetation. There is another of its kind, however (*P. fruticosa*), which really grows into a

regular shrub, with many branches, terminated by large trusses of bright-yellow flowers. Asa Gray says this plant is "common northward" in wet ground, but I was not lucky enough to hit upon it during my visit to America. However, I have seen living specimens from Teesdale in England, and from them I perceive that, in general habit, the plant greatly approaches the rock-roses (*Helianthemum*), which grow in very similar situations. The leaflets of the shrubby potentilla, long, narrow, and silky beneath, resemble, at first glance, the leaves of the rock-roses, thus showing how similar conditions tend everywhere to produce similar results, even when starting from the most unlike organic forms to begin with.

One other potentilla, the goose-weed or silver-weed (*P. anserina*), I must needs mention for form's sake, though I have nothing special to say about it. It is a creeping species, growing close to the ground, with long pinnate and prostrate leaves, silvery white below, with silky down. Both in Europe and America it is very common as a road-side weed, and in moist ditches; but with us it is a weedier and scurvier plant than with you—evidently a sufferer from our long civilization. In America it grows mostly by river-banks and in brackish marshes; in Europe, it belongs rather to waste places and stony pastures than to streams or mud-banks. Few temperate plants, however, have a wider distribution. It is a circumpolar weed in both great continents, extending through Russia and Siberia to Alaska and British America, and it reappears once more, under like conditions, in the southern hemisphere. Nothing kills it out, and it will bear both inundation and trampling under foot to a greater degree than any other plant of equal importance.

The handsomest of your American potentillas, however, is the marsh five-finger (*P. comarum* or *palustris*), a very bold and elegant water-side plant, bluish-green in stem and leaves, and with loose corymbs of exceedingly pretty though dingy flowers. The calyx, inside, is lurid-red, and the large petals are tinged with a gloomy and peculiar purple. This fine ornamental plant loves cool northern bogs and marshes, being common in Canada and in the Scotch Highlands. But what gives it to me the deepest interest is its exact resemblance in hue and general aspect to a purple avens (*Geum rivale*), also common to either hemisphere. Both are plants of the cold swamps and peaty places; both depend for fertilization upon water-side insects; both have lurid-reddish calyxes, and both have large and dingy purplish petals. The inference seems to me irresistible that the color has been evolved in both cases by the special tastes of the upland water-creatures to whose aid both owe the impregnation of their ovules. Indeed, it is often easy thus to classify flowers functionally by their color and the tastes of the particular insects that habitually visit them. In Europe, at least, I believe the particular insect in this case to be *Rhingia rostrata*, which I have observed in great abundance upon both flowers. Amer-

ican naturalists, please verify, or look out for, the corresponding American species.

On the Alpine summits of the White Mountains, and far to the north again in the Labrador region, there grows abundantly a little matted mountain plant, not recognized by the scientific world at large as a potentilla at all, and known by the name of *Sibbaldia procumbens*. But you may call the plant whatever you like without altering the undeniable fact that it is in all essentials a dwarfed and depressed mountain potentilla, with the flowers so reduced by chilly conditions that very few stamens or carpels remain, and with the usual dense, spreading, tufty habit common to all Alpine vegetation. It is clearly descended from a high hill-side potentilla not unlike the white *P. tridentata* of Mount Willard aforesaid (only with yellow flowers), for it has the same type of tre-foil leaves, with each leaflet three-toothed at the end, and the same general aspect and habit. Both plants, I do not doubt, are common descendants of a single antique Arctic ancestor. But little *Sibbaldia* has grown so very small and degraded in time that its flowers have dwindled away almost to nothing; the green calyx forms its most conspicuous part; the pale-yellowish petals are very tiny, and in many cases are entirely wanting. In the States *Sibbaldia* is confined to the higher summits of the White Mountains; but in the Scotch Highlands, as in the far north of British America, it often constitutes for miles together the main element of the low and matted mountain greensward.

Last among your American potentillas I may mention the wild strawberries. Though these at first sight seem somewhat different from the rest of the group, I have not the slightest hesitation in saying that to the evolutionary botanist they can not but appear as closely related species of one and the same natural genus. For the strawberries are only potentillas in which the receptacle of the fruit, instead of remaining hard and dry, swells out into a colored and pulpy mass, attractive to birds, who thus aid in dispersing the tiny "achenes" or nutlets (commonly, and for all practical purposes correctly enough, described as seeds). To us in Europe, the essential identity of the two types is made all the more evident, because we happen to possess a little three-leafleted white potentilla (*P. fragariastrum*) so exactly like a wild-strawberry vine in foliage and flower that few save botanists or close observers of Nature ever adequately distinguish between them. This white potentilla is, in fact, a strawberry in everything essential except the fruit; and the succulence of the fruit (or rather receptacle) is after all a matter of comparatively little importance except to the men and birds who eat it. I am fully convinced that if the strawberry had not been an edible berry it would always have been classed merely as a potentilla, and considered as very closely analogous to the *P. fragariastrum* or "barren strawberry" of Northern Europe. It is hardly more, indeed, than a mere variety.

You have in America two slightly divergent forms of the wild strawberry, erected into species by American botanists, for small differences in the appearance of the berry. Had these differences occurred in any other than an edible fruit they would, I am sure, hardly have been noticed: occurring there, they have been suffered to assume a factitious importance in the eyes of systematizers. One of these varieties (*Fragaria vesca*), which grows in fields and open places, is the common wild strawberry of Europe; but it bears somewhat larger berries with you than with us, and has a somewhat more erect and noble habit. Apparently it is proud of its American citizenship. It is distinguished by having the nutlets merely superficial on the outside of the berry, not sunk in pits, as in the second variety. This last-named form (*F. Virginiana* or *F. Canadensis*) is peculiar to America, and differs from the European type in the constricted or bottle-shaped neck of the berry, and in the deep depressions for the nutlets, the ribs between which accordingly give the fruit a distinctly pitted or spiny appearance. It is a woodland plant, native to your forests, and far more forestine in aspect and habit than our English vine. In flavor, also, it differs distinctly, and your cultivated Virginia scarlets are its final product in the gardeners' hands. The Western variety (*Illinoensis*), according to Gray, gives origin to Hovey's seedling, the Boston pine, and many other cultivated strains. No European strawberry can at all equal these native American fruits in delicacy of flavor.

There is a third species of strawberry, undoubtedly distinct, admitted by Gray as a naturalized American, which possesses for me a peculiar interest. This is the *Fragaria Indica*, or *Duchesnea fragarioides*, a Himalayan species, established in copses round Philadelphia and at various places in the Southern States. Some years ago a plant of this curious species was sent to me in a box for identification: I set it out, on the off chance of its living, in my garden at Dorking; and it now overruns the whole place, so that I have had abundant opportunities of observing its growth and development to my heart's content. I am certain that *F. Indica* is not a true strawberry at all; or, in other words, that it is not a common descendant with the other strawberries of any original white-flowered potentilla ancestor, but an independent development of the succulent habit all by itself. It has yellow blossoms, a very different calyx, and a most insipid, pulpy fruit. I have not the slightest doubt that this species has been developed from a yellow Indian potentilla, just as our strawberries have been developed from a white European potentilla, by the unconscious agency of birds in dispersing the nutlets. All that the two plants have in common (beyond their undoubted generic potentilla type) is the mere fact of a succulent receptacle, which might just as easily occur independently in the one case as in the other. If I had to remodel the genus *Potentilla* on my own account, I would certainly put

the common strawberry into the same division as the white-flowered European *P. fragarioides*, while I would put the Indian species into the same division with the yellow-flowered *P. frigida* of your Mount Washington range.

THE RISE OF THE GRANGER MOVEMENT.

By CHARLES W. PIERSON.

SOME wise men of the press are saying that the Knights of Labor are like the Grangers. As the exact points of resemblance are not stated, the assertion serves merely to call up a recollection of the unique secret society, which, a dozen years ago, seemed far more powerful than ever the Knights of Labor were. The Grange still lives, but its glory is departed, and its history is recorded only in the distorted statements of partisans and of misinformed review-writers.

In the latter part of 1868 certain Minnesota farmers received a printed sheet which began as follows: "In response to numerous inquiries in regard to our order, this circular is issued. The order was organized by a number of distinguished agriculturists of various States of the Union at Washington in December, 1867, and since then has met with most encouraging success, giving assurances that it will soon become one of the most useful and powerful organizations in the United States. Its grand object is not only general improvement in husbandry, but to increase the general happiness, wealth, and prosperity of the country." As an aid in accomplishing its author's design, this circular was certainly a success. As a statement of truth it was a conspicuous failure. Instead of having "met with most encouraging success," the order had scarcely been heard of; while the "distinguished agriculturists" who had "organized" it comprised one fruit-grower and six Government clerks, equally distributed among the Post-Office, Treasury, and Agricultural Departments. Of these seven Immortal Founders, as enthusiastic Grangers were calling them a few years later, six are living. Nevertheless, it is difficult to determine just how much of the plan and its execution was due to each. The truth seems to be about as follows: In 1866 one O. H. Kelley, a clerk in the Agricultural Department, was sent by the Commissioner of Agriculture on a tour of inspection through the Southern States. Impressed with the demoralization of the farming population, he hit upon the idea of organization for social and educational purposes, as a means for these people to better their condition. An ardent Mason, he naturally thought of an organization similar to the Masonic, in whose ritual, secrecy, and fraternity he saw the secret of that permanence which all agricultural societies had failed to attain. A niece in Boston, to whom he first mentioned the idea, recommended that women be given membership, thus originating an important feature.

On returning to Washington, Kelley took the other six immortals into his confidence, and the seven set about developing the plan and constructing a ritual. It would be a long story to tell how, by two years' labor in the intervals of their regular work, they constructed a constitution providing for a national, State, county, and district organization, and a ritual with seven degrees; how the names—Patrons of Husbandry for the body in general and Grangers for the subordinate chapters—were finally hit upon, the latter being taken, not on account of its etymological meaning (Latin *granum*), but from the name of a recent novel. Suffice it to say that on December 4, 1867, a day still celebrated as the birthday of the order, the seven assembled, and, with an assurance almost sublime, solemnly organized themselves as the "National Grange of the Patrons of Husbandry." There was none to dispute the title, and they enjoyed it alone for the next five years. It is hard to tell just what were the expectations of these men. Kelley has been called everything from an unselfish philanthropist to a scheming adventurer. One can not but admire the pluck with which he persevered through great discouragements, and the unselfish spirit in which he and his fellow-workers surrendered control of the movement when it had become a power in the land. Their first step was to organize a mock Grange among their fellow-clerks and their wives, to experiment with the ritual. The experiment proving satisfactory, Kelley resigned his clerkship and started out to proclaim the Grange to the world, armed only with a few dollars and a sort of introductory letter from the other six to mankind at large.

He was not a success as a lecturer. Moreover, he made the mistake of laboring in the larger towns, instead of in the country. The four or five Granges that he coaxed into life at once proceeded to die, and he finally reached Minnesota penniless, but not discouraged. Even while the six at Washington were becoming faint-hearted, and writing to him that the landlady was pressing them grievously for hall-rent, and that it would be wise to give up the whole business, he could issue the circular with which I began, dilating upon the success of the order and the distinguished agriculturists at Washington who founded it. At his home, near Itasca, he worked on furiously, now dodging a creditor, again obliged to postpone answering letters for want of means to buy postage-stamps, till finally signs of success began to appear. He had organized a few Granges in Minnesota, and was able to detect a growing interest in other States. The prime necessity now was to encourage this feeble beginning, and by all means to keep it under the delusion that it was part of a powerful national organization. To this end every cent that could be earned or borrowed was used in distributing photographs of the founders, along with a mass of circulars and documents purporting to come from the national office at Washington. Every important question was ostensibly referred by Kelley to the Executive Committee at the same

place, and the decisions and power of this mythical body were held in great awe by the Patrons. But other men were becoming interested and going to work. In Minnesota they were able to organize a State Grange, having mustered the fifteen district Granges required by the constitution. Two years later the State Grange of Iowa was organized, and its Worthy Master crossed the country to attend what the founders were pleased to call the "Fifth Annual Session of the National Grange." He was the first member of the order to meet with the seven. What he thought on ascertaining the real state of things is not recorded. However, he did not give up the work, and later he became Worthy Master of the National Grange. The order kept growing. At the sixth annual session, held at Georgetown in January, 1873, there were delegates from eleven States, and four women were present; 1,074 Granges had been organized during the year. The founders now gave up their offices, not even reserving the right to vote, and delivered over the results of six years' labor to their successors. For the first time, the greatest of farmers' societies was in the hands of farmers!

The next two years were years of astounding growth—a growth almost unparalleled in the history of secret organizations, and resembling that of the Know-Nothings twenty years before. At the end of 1872 about 1,300 Granges had been organized. In the year 1873, 8,668 more were added; and in 1874, 11,941, making a total of almost 22,000, with an average membership of forty. Some idea of the magnitude of these figures may be gained from the fact that the whole number of lodges of Masons and Odd-Fellows in the world is estimated at about 20,000. The order was represented in every State except Rhode Island (which has never found room for it). It had been established in the Indian Territory, whence it appealed for help to the National Grange because the governor of the Chickasaw nation looked on it with suspicion, and had ordered all Grangers out of the Chickasaw country. It had taken root in Canada, where, a few years later, there were 860 subordinate Granges. One deputy introduced it into England; others were laboring in France and Germany; and inquiries and invitations were coming even from Australia and Tasmania.

Grange treasuries were overflowing. In 1873 and 1874 the dues to the National Grange alone, according to the official statement, amounted to $348,532.20. The press was discussing the new order with alarm. Legislative committees were scurrying about the country to see what could be done for the farmer. In the words of the New York "Nation," "the farmer was the spoiled child of our politics." The House of Representatives at Washington was overawed at the new power that was apparently rising in politics, and those who claimed, for the most part falsely, to represent the movement enjoyed an astonishing influence. Among other legislation secured by these men, one

bill was rushed through for printing and distributing to the farmers certain agricultural documents, at an expense of $500,000! W. W. Phelps opposed it, only to be bitterly attacked on the score of sympathy with monopolists and lack of sympathy with farmers. One fervid orator from Kansas went over his whole record for proofs of this, and alleged many damaging facts—among them that he was rich, that he was interested in banks and railroads, and that he had been graduated with honor from Yale College. "These Grangers," exclaimed the orator, "mean business; . . . they are chosen to be the *sovereigns* of the mightiest republic of earth." Various cities strove for the honor of having the National Grange offices located within their limits, one offering to give a splendid building, another, to furnish necessary office-room and an annuity of $5,000 for five years, but the Grange was rich and independent in those days. At the seventh annual session held at St. Louis in 1874, a declaration of purposes was adopted which still remains the official statement. I can quote but fragments of this creditable document: "We shall endeavor . . . to enhance the comforts and attractions of our homes, and strengthen our attachment to our pursuits; to foster co-operation; . . . to diversify our crops; to condense the weight of our exports, selling less in the bushel and more on hoof and in fleece; to discountenance the credit system, the mortgage system, the fashion system, and every other system tending to prodigality and bankruptcy. We propose meeting together, buying together, selling together. We wage no aggressive warfare against any other interests whatever; . . . we hold that transportation companies are necessary to our success, that their interests are intimately connected with our interests, and that harmonious action is mutually advantageous. *We are not enemies of railroads.* In our noble order there is no communism, no agrarianism; we emphatically assert the truth taught in our organic law that the Grange is not a political or party organization. No Grange, if true to its obligations, can discuss political or religious questions, nor call political conventions, nor nominate candidates, nor even discuss their merits in its meetings." It is to be noted that this is 1874, at the height of the "Anti-Railroad" and "Farmers' party" excitement.

The Grange had now reached the zenith of its power. One year later, in the stormy meeting held at Charleston, a measure was passed for the distribution of the surplus revenue of the National Grange, which may be said to mark the beginning of Grange decadence. But a consideration of this decadence may well be postponed for a time.

Any discussion of the causes of the Grange's astonishing growth has been deferred to this point, in order that they may be considered in connection with the railroad legislation of the early seventies, with which the Grange, to most minds, is so entangled. The spirit of enterprise following the war found vent in developing the resources of the upper Mississippi Valley. Emigration from Europe thither in-

creased greatly after the close of hostilities, and the tide was swelled by men turned adrift in the disbanding of the armies. The cry was for railroads to open the country, and the speculative spirit, induced by an inflated currency, was quick to second it. Land-grants of enormous extent were made by the General and State governments, and Western municipalities vied with each other in bonding themselves to offer inducements to railroad-building. In the years 1865–'71, $500,000,000 was invested in Western railroads. D. C. Cloud, in his "Monopolies and the People," makes the statement that "one acre out of every eight and a half of the entire area of Iowa has been given away to railroad corporations. . . . There were land-grants, subsidies, bonds, subscriptions, and taxes to the amount of five per cent of our entire valuation in one year." Every farmer wanted a railroad, and every one with any pretense to economic knowledge wanted two, to keep down charges by competition! Railroads and population reacted on each other. The consequence was, that both railroads and population moved too far west, accumulating debt in the inflated currency as they went. There was little traffic for the railroads in anything but grain. So long as the price of this was high, all went well, and they were suffered to go on their reckless way with little remark save a clamor for more competing roads where the pinch of discrimination was felt. But conditions changed. The price of wheat began to show the effect of the enormous increase of production. The demand caused by the Prusso-Austrian and Franco-German wars ceased. The grasshopper became a burden. The farmers, who had gone into debt in flush times, felt the pinch of an appreciating currency. A villainous tariff, increasing the cost of transportation and of everything they bought, conspired with the rest to produce unavoidable distress. Add to all this the crisis of 1873, and it is not strange that there was a "Farmers' Movement." "Organize!" was the universal cry, and there were as many reasons for it, in the farmer's mind, as he had needs and grievances, fancied or real, and these were legion. Owing to the change in economic conditions, wheat could no longer pay transportation charges and be profitable. According to the report of the Senate Committee on Transportation to the Seaboard, the average price of wheat in Chicago fell thirty-three cents from 1868–'72, while the charge for transportation to the East fell but nine cents. The farmer was forced to feed his grain to his cattle or use it for fuel. In this state of things the railroad loomed up before him as the only obstacle between himself and his hungry Eastern brother, whose needs he was anxious to supply—for a fair compensation. A toll for transportation exceeding the price he received seemed *a priori* a monstrous extortion. To aggravate matters, the railroads were run with unparalleled short-sightedness. The term "railroad official" was a synonym for insolence. There had been great corruption in the building of many of the roads, and such imperfectly comprehended terms as "Crédit

Mobilier," "watered stock," and "Wall Street speculation," were in everybody's mouth. Most of the stock was owned in the East and in Europe, and the expression "absentee ownership" began to arouse somewhat the same feeling as in Ireland. The "Nation" pleaded for the widows and orphans who were kept from want only by their railroad-stock, but the farmer replied that the stock was in the hands of such orphans as Commodore Vanderbilt and Jay Gould, who could look out for themselves. Add the fact that the railroads felt the hard times as much as the farmers; that for very self-preservation the traffic at competing points was so furiously fought for as to make rates ruinously low, while each road extorted all it could squeeze where there was no competition, and it will not seem strange that the "Farmers' Movement" developed, on one side, into a political organization to fight railroads. But this was not the Grange. A misconception exists on this point. In everything published on the subject, the anti-railroad movement is called the Granger movement; the resulting legislation, the Granger legislation; the cases that arose, the Granger cases. It must be granted that the same farmers often were engaged in both movements, and that certain subordinate parts of the Grange did sometimes disobey their organic law so far as to engage as bodies in the agitation, chiefly by memorializing Legislatures. It was impossible to control completely the rank and file of such a vast order. But, with these reservations, the Grange, as an organization, took no part in the anti-railroad agitation. The two were not cause and effect, but parallel effects of the same general causes. In the way of proof the "Declaration of Purposes" of 1874 has already been quoted, to the effect that the Grange is not hostile to railroads, and that all political action and discussion is totally excluded. The published proceedings of the National Grange show the same thing. In 1874 the executive committee reported: "Unfortunately for the order, the impression prevails to some extent that its chief mission is to fight railroads." In 1875 a resolution from Texas favoring railroad legislation was suppressed. In 1873 the Master of the Minnesota State Grange, being informed that certain Granges in his jurisdiction had appointed delegates to a State anti-railroad convention, ordered the offending Granges to recall their delegates. Congressman D. W. Aiken, of South Carolina, long a member of the National Executive Committee, said in an address four years ago: "Frequently had the Grange to bear the odium of other men's sins. . . . For instance, there existed in Illinois and Wisconsin, and other sections of the Northwest, agricultural clubs whose province seemed to be to wage war against transportation companies. Anathemas were hurled upon the Grange for making this attack, whereas every Patron of Husbandry knew that the Grange as such was not a participant in the fight from beginning to end." It may seem surprising that such an error should have arisen, but it is not inexplicable. The newspapers first applied the name "Grangers"

to Western farmers in general, and consequently to those fighting railroads. From this it was an easy step to the assertion that the Grange was the fighting organization. There were some exceptions. The "Tribune" sent a special correspondent West, and afterward published a "Farmers' Extra," in which it is expressly recognized that the Grange is not fighting railroads, though some Grangers are. The "Times" published the same discovery with the comment that the general impression on this point was a mistaken one. But the "Nation," which talked loudest of all, and the press in general, made no such distinction. It is not strange that Mr. C. F. Adams and other writers on railroads have followed this leading, as it was of no consequence to them whether the Western agitators were known as "Grangers" or by any other name. The principal difficulty is with those who wrote from the farmers' standpoint. It can only be said that they wrote before the railroad legislation had been given a fair trial, and that they wanted to claim for the order the credit of what looked like a success. Their books, in general, are of a hortatory and prophetic rather than historical character.

From this point of view it may seem foreign to our subject to discuss the railroad agitation further. Its intimate connection with the Granger movement, however, and the causal relation between the two in the public mind, may furnish excuse. In 1867, when the Grange was founded at Washington, most of the Western States were still passing laws to facilitate municipal and other aid to railroads. A few, however, were beginning to take the alarm, and about 1867 six made feeble attempts to check the growing abuses; from Iowa, which merely affirmed the full liability of the railroads as common carriers, to Ohio, where a "Commissioner of Railroads and Telegraph" was provided for. The feeling grew during the next three years. Illinois, for example, passed an act in 1869 providing that "all railroad corporations shall be limited to a just, reasonable, and uniform toll." These facts are mentioned to show—not tangible results, for they were not attained, but the growth of public feeling prior to the adoption of the new State Constitution by Illinois in 1870, which, with the bills immediately following, first awakened the country at large to the fact that something was brewing among the Western farmers. The Constitution of 1870 declares: "Railroads . . . are hereby declared public highways, and the General Assembly shall . . . pass laws establishing reasonable maximum rates. . . . No municipality shall ever become subscriber to the capital stock of any railroad." The attack was followed up in 1871 by an act establishing a system of maxima, and providing for a Board of Commissioners to put to each company forty-one specified questions and as many more as their ingenuity might devise. The railroads, relying on the Dartmouth College case, declared the law unconstitutional and refused to obey it. In the suits that arose, Judge Lawrence, of the State Supreme Court, pronounced the fixing of maxima

by statute unconstitutional with reference to the new State Constitution, expressing no opinion on the point claimed by the railroads—that this Constitution itself was contrary to the clause in the United States Constitution in regard to impairing the obligation of contracts. Coming up for re-election, Judge Lawrence was defeated, to the astonishment of himself and everybody else, by a combination of farmers. Emboldened by success, the farmers held nominating conventions, and managed to elect several circuit judges, and county tickets in nearly half the counties. A great mass-meeting was held at Springfield during the session of the Legislature in that city, to urge upon it the necessity of a new railroad bill. The Legislature, nothing loath, passed the law of 1873, avoiding the point made by Lawrence against that of 1871 by providing for "reasonable" instead of "maximum" rates, and making it the duty of the commissioners to draw up a schedule of such rates. Provision was made that they be ideally unfit for the task in the following section: "No person shall be appointed who is in any way connected with any railroad company, or who is, directly or indirectly, interested in any stock or bond." It is no wonder that their schedule was as fearfully and wonderfully made as a United States tariff list. The "Nation" called it "a crazy table of rates drawn up by a mob of ignorant and excited politicians." The system had one advantage, however, over a cast-iron set of maxima fixed by statute. It could be modified or made inoperative as the information of the commissioners grew, and this is what was done in Illinois. Early in 1873 the "American Cheap Transportation Company" was organized at the Astor House, and later in the year two other great mass-meetings were held in Illinois. They accomplished only a great waste of pyrotechnic eloquence. Demagogues and sharpers had taken control, and the real movers had quietly dropped out.

In spite of the assertions of Mr. C. F. Adams and others, it can be shown that the Grange was not responsible for the Illinois legislation. When the Constitution of 1870 and the law of 1871 were passed, the Grange had scarcely a foothold in the State. The State Grange was organized in March, 1872. The real organ of agitation was the "State Farmers' Association," whose subordinate lodges were called "Farmers' Clubs." Its president, W. C. Flagg, testified before the Windom committee in 1873 that he was not a Granger, that his organization was an open and political one, while the Grange was secret and non-political, disavowing and preventing, as far as it could, any political action.

By 1874 seven States had passed so-called "Granger" laws, either fixing maxima or providing for a commission to make out a schedule of rates. The Iowa bill, on the former model, devoted twenty-six pages to a classification of freight. But all this was surpassed in Wisconsin. In 1873 there appeared in the State Senate a certain Potter, from Wautoma, Waushara County. It was said that his county

did not contain a mile of railroad, and he probably knew as little about railroads as any other man in the Legislature; at least, to believe the contrary would require a very pessimistic view of Wisconsin intelligence. March 11, 1874, the famous "Potter Bill" became a law. Mr. Potter is said to have made it up by calling for suggestions and incorporating those most disadvantageous to the railroads. At any rate, it was bad enough at first, and the railroad interest worked to increase its enormities, hoping to get it into a shape that they could defeat. They were mistaken. The bill passed, and the Governor celebrated some speedy victories in the courts by firing cannon.

Meanwhile cases were before the Supreme Court on the validity of all this legislation. The court recognized the gravity of the question and reserved its decision, affirming the constitutionality of the laws, for more than a year after the test case (Munn *vs.* Illinois) was argued. The gist of the decision is in the following words: "When one devotes his property to a use in which the public has an interest, he, in effect, grants the public an interest in that use, and must submit to be controlled by the public for the common good to the extent of the interest he has thus created." The decisions in this, and the six other "Granger" cases, were pronounced by Chief-Justice Waite, Justices Field and Strong dissenting.

In the courts the farmers were victorious. But, unfortunately, the Supreme Court does not pass upon economic laws, and to these the movement had already succumbed. By the time the cases were decided, in 1876–'77, scarcely one of the statutes in question remained in force. In the second year under the Potter law, no Wisconsin road paid a dividend, and only four paid interest on their bonds. Foreign capitalists refused to invest further in the State. On the recommendation of the Governor, the very men who had passed the law hurriedly repealed it. In the next year Mr. Potter faded out of American politics, and his place in the Senate was filled by another. Most of the other States also beat a precipitate retreat, poorly covered by a faint demonstration against unreasonableness in general.

So the victors were beaten, and bad times made the defeat seem worse than it was. But they claim, and not without reason, to have done lasting good. The attitude of railroad corporations is very different from what it was twelve years ago. More of the old grievances have disappeared than is generally supposed. To this movement we owe the railroad commissions found in so many States. How much they are worth is, of course, a matter for dispute. The power of the railroads to reward or punish is so real and present, while that of the people at large is so indefinite and far away, that it is not strange if the ordinary commissioner inspires about the same terror as does the gingerbread lion. Of late the Grange, forgetting its record, has been claiming the credit for all the good accomplished. It is gravely asserted that a resolution of the National Grange in 1874 caused the

appointment of the Windom Committee on Transportation in 1872. In New York, Grangers boast of the Hepburn Commission of 1879, and claim to have defeated a railroad man, C. M. Depew, for the Senate in 1881. And doubtless the Interstate Commerce Bill will be hailed as one more achievement.

NOTE.—The progress and decline of the Granger movement will be considered in a later article.—ED.

THE BOYHOOD OF DARWIN.*

BY HIMSELF.

[MY father's autobiographical recollections, given in the present chapter, were written for his children—and written without any thought that they would ever be published. To many this may seem an impossibility; but those who knew my father will understand how it was not only possible but natural. The autobiography bears the heading, "Recollections of the Development of my Mind and Character," and ends with the following note: "August 3, 1876. This sketch of my life was begun about May 28th at Hopedene,† and since then I have written for nearly an hour on most afternoons." It will easily be understood that, in a narrative of a personal and intimate kind, written for his wife and children, passages should occur which must here be omitted; and I have not thought it necessary to indicate where such omissions are made. It has been found necessary to make a few corrections of obvious verbal slips, but the number of such alterations has been kept down to the minimum.—F. D.]

A GERMAN editor having written to me for an account of the development of my mind and character, with some sketch of my autobiography, I have thought that the attempt would amuse me, and might possibly interest my children or their children. I know that it would have interested me greatly to have read even so short and dull a sketch of the mind of my grandfather, written by himself, and what he thought and did, and how he worked. I have attempted to write the following account of myself as if I were a dead man in another world looking back at my own life. Nor have I found this difficult, for life is nearly over with me. I have taken no pains about my style of writing.

I was born at Shrewsbury on February 12, 1809, and my earliest recollection goes back only to when I was a few months over four years old, when we went to near Abergele for sea-bathing, and I recollect some events and places there with some little distinctness.

* From advance sheets of "Life and Letters of Charles Darwin," by his Son, Francis Darwin. New York: D. Appleton & Co.

† Mr. Hensleigh Wedgwood's house in Surrey.

My mother died in July, 1817, when I was a little over eight years old, and it is odd that I can remember hardly anything about her except her death-bed, her black-velvet gown, and her curiously-constructed work-table. In the spring of this same year I was sent to a day-school in Shrewsbury, where I stayed a year. I have been told that I was much slower in learning than my younger sister Catherine, and I believe that I was in many ways a naughty boy.

By the time I went to this day-school* my taste for natural history, and more especially for collecting, was well developed. I tried to make out the names of plants,† and collected all sorts of things—shells, seals, francs, coins, and minerals. The passion for collecting which leads a man to be a systematic naturalist, a virtuoso, or a miser, was very strong in me, and was clearly innate, as none of my sisters or brother ever had this taste.

One little event during this year has fixed itself very firmly in my mind, and I hope that it has done so from my conscience having been afterward sorely troubled by it; it is curious as showing that apparently I was interested at this early age in the variability of plants! I told another little boy (I believe it was Leighton, who afterward became a well-known lichenologist and botanist) that I could produce variously-colored polyanthuses and primroses by watering them with certain colored fluids, which was of course a monstrous fable, and had never been tried by me. I may here also confess that as a little boy I was much given to inventing deliberate falsehoods, and this was always done for the sake of causing excitement. For instance, I once gathered much valuable fruit from my father's trees and hid it in the shrubbery, and then ran in breathless haste to spread the news that I had discovered a hoard of stolen fruit.

I must have been a very simple little fellow when I first went to the school. A boy of the name of Garnett took me into a cake-shop one day, and bought some cakes for which he did not pay, as the shopman trusted him. When we came out I asked him why he did not pay for them, and he instantly answered, "Why, do you not know that my uncle left a great sum of money to the town on condition that every

* Kept by Rev. G. Case, minister of the Unitarian Chapel in the High Street. Mrs. Darwin was a Unitarian and attended Mr. Case's chapel, and my father, as a little boy, went there with his elder sisters. But both he and his brother were christened and intended to belong to the Church of England; and after his early boyhood he seems usually to have gone to church and not to Mr. Case's. It appears ("St. James's Gazette," December 15, 1883) that a mural tablet has been erected to his memory in the chapel, which is now known as the "Free Christian Church."

† Rev. W. A. Leighton, who was a schoolfellow of my father's at Mr. Case's school, remembers his bringing a flower to school and saying that his mother had taught him how, by looking at the inside of the blossom, the name of the plant could be discovered. Mr. Leighton goes on, "This greatly roused my attention and curiosity, and I inquired of him repeatedly how this could be done?"—but his lesson was, naturally enough, not transmissible.

tradesman should give whatever was wanted without payment to any one who wore his old hat and moved [it] in a particular manner?" and he then showed me how it was moved. He then went into another shop where he was trusted, and asked for some small article, moving his hat in the proper manner, and of course obtained it without payment. When we came out he said, "Now, if you like to go by yourself into that cake-shop" (how well I remember its exact position,) "I will lend you my hat, and you can get whatever you like if you move the hat on your head properly." I gladly accepted the generous offer, and went in and asked for some cakes, moved the old hat, and was walking out of the shop, when the shopman made a rush at me, so I dropped the cakes and ran for dear life, and was astonished by being greeted by shouts of laughter by my false friend Garnett.

I can say in my own favor that I was as a boy humane, but I owed this entirely to the instruction and example of my sisters. I doubt, indeed, whether humanity is a natural or innate quality. I was very fond of collecting eggs, but I never took more than a single egg out of a bird's nest, except on one single occasion, when I took all, not for their value, but from a sort of bravado.

I had a strong taste for angling, and would sit for any number of hours on the bank of a river or pond watching the float. When at Maer* I was told that I could kill the worms with salt and water, and from that day I never spitted a living worm, though at the expense probably of some loss of success.

Once as a very little boy while at the day-school, or before that time, I acted cruelly, for I beat a puppy, I believe, simply from enjoying the sense of power; but the beating could not have been severe, for the puppy did not howl, of which I feel sure, as the spot was near the house. This act lay heavily on my conscience, as is shown by my remembering the exact spot where the crime was committed. It probably lay all the heavier from my love of dogs being then, and for a long time afterward, a passion. Dogs seem to know this, for I was an adept in robbing their love from their masters.

I remember clearly only one other incident during this year while at Mr. Case's daily school—namely, the burial of a dragoon-soldier; and it is surprising how clearly I can still see the horse with the man's empty boots and carbine suspended to the saddle, and the firing over the grave. This scene deeply stirred whatever poetic fancy there was in me.

In the summer of 1818 I went to Dr. Butler's great school in Shrewsbury, and remained there for seven years till midsummer, 1825, when I was sixteen years old. I boarded at this school, so that I had the great advantage of living the life of a true school-boy; but as the distance was hardly more than a mile to my home, I very often ran there in the longer intervals between the callings over and before locking up

* The house of his uncle, Josiah Wedgwood.

at night. This, I think, was in many ways advantageous to me by keeping up home affections and interests. I remember in the early part of my school-life that I often had to run very quickly to be in time, and from being a fleet runner was generally successful; but when in doubt I prayed earnestly to God to help me, and I well remember that I attributed my success to the prayers and not to my quick running, and marveled how generally I was aided.

I have heard my father and elder sister say that I had, as a very young boy, a strong taste for long, solitary walks; but what I thought about I know not. I often became quite absorbed, and once, while returning to school on the summit of the old fortifications round Shrewsbury, which had been converted into a public foot-path with no parapet on one side, I walked off and fell to the ground, but the height was only seven or eight feet. Nevertheless, the number of thoughts which passed through my mind during this very short but sudden and wholly unexpected fall, was astonishing, and seem hardly compatible with what physiologists have, I believe, proved about each thought requiring quite an appreciable amount of time.

Nothing could have been worse for the development of my mind than Dr. Butler's school, as it was strictly classical, nothing else being taught, except a little ancient geography and history. The school as a means of education to me was simply a blank. During my whole life I have been singularly incapable of mastering any language. Especial attention was paid to verse-making, and this I could never do well. I had many friends, and got together a good collection of old verses, which, by patching together, sometimes aided by other boys, I could work into any subject. Much attention was paid to learning by heart the lessons of the previous day; this I could effect with great facility, learning forty or fifty lines of Virgil or Homer, while I was in morning chapel; but this exercise was utterly useless, for every verse was forgotten in forty-eight hours. I was not idle, and, with the exception of versification, generally worked conscientiously at my classics, not using cribs. The sole pleasure I ever received from such studies was from some of the odes of Horace, which I admired greatly.

When I left the school I was for my age neither high nor low in it; and I believe that I was considered by all my masters and by my father as a very ordinary boy, rather below the common standard in intellect. To my deep mortification my father once said to me, "You care for nothing but shooting, dogs, and rat-catching, and you will be a disgrace to yourself and all your family." But my father, who was the kindest man I ever knew, and whose memory I love with all my heart, must have been angry and somewhat unjust when he used such words.

Looking back as well as I can at my character during my school-life, the only qualities which at this period promised well for the future were, that I had strong and diversified tastes, much zeal for whatever interested me, and a keen pleasure in understanding any

complex subject or thing. I was taught Euclid by a private tutor, and I distinctly remember the intense satisfaction which the clear geometrical proofs gave me. I remember, with equal distinctness, the delight which my uncle gave me (the father of Francis Galton) by explaining the principle of the vernier of a barometer. With respect to diversified tastes, independently of science, I was fond of reading various books, and I used to sit for hours reading the historical plays of Shakespeare, generally in an old window in the thick walls of the school. I read also other poetry, such as Thomson's "Seasons," and the recently published poems of Byron and Scott. I mention this because later in life I wholly lost, to my great regret, all pleasure from poetry of any kind, including Shakespeare. In connection with pleasure from poetry, I may add that in 1822 a vivid delight in scenery was first awakened in my mind, during a riding tour on the borders of Wales, and this has lasted longer than any other æsthetic pleasure.

Early in my school-days a boy had a copy of the "Wonders of the World," which I often read, and disputed with other boys about the veracity of some of the statements; and I believe that this book first gave me a wish to travel in remote countries, which was ultimately fulfilled by the voyage of the Beagle. In the latter part of my school-life I became passionately fond of shooting; I do not believe that any one could have shown more zeal for the most holy cause than I did for shooting birds. How well I remember killing my first snipe, and my excitement was so great that I had much difficulty in reloading my gun from the trembling of my hands! This taste long continued, and I became a very good shot. When at Cambridge, I used to practice throwing up my gun to my shoulder before a looking-glass, to see that I threw it up straight. Another and better plan was to get a friend to wave about a lighted candle, and then to fire at it with a cap on the nipple, and if the aim was accurate the little puff of air would blow out the candle. The explosion of the cap caused a sharp crack, and I was told that the tutor of the college remarked, "What an extraordinary thing it is, Mr. Darwin seems to spend hours in cracking a horse-whip in his room, for I often hear the crack when I pass under his windows!"

I had many friends among the school-boys whom I loved dearly, and I think that my disposition was then very affectionate.

With respect to science, I continued collecting minerals with much zeal, but quite unscientifically—all that I cared about was a new-*named* mineral, and I hardly attempted to classify them. I must have observed insects with some little care, for when, ten years old (1819), I went for three weeks to Plas Edwards on the sea-coast in Wales, I was very much interested and surprised at seeing a large black and scarlet hemipterous insect, many moths (*Zygæna*), and a cicindela, which are not found in Shropshire. I almost made up my mind to be-

gin collecting all the insects which I could find dead, for, on consulting my sister, I concluded that it was not right to kill insects for the sake of making a collection. From reading White's "Selborne," I took much pleasure in watching the habits of birds, and even made notes on the subject. In my simplicity I remember wondering why every gentleman did not become an ornithologist.

Toward the close of my school-life, my brother worked hard at chemistry, and made a fair laboratory with proper apparatus, in the tool-house in the garden, and I was allowed to aid him as a servant in most of his experiments. He made all the gases and many compounds, and I read with great care several books on chemistry, such as Henry and Parkes's "Chemical Catechism." The subject interested me greatly, and we often used to go on working till rather late at night. This was the best part of my education at school, for it showed me practically the meaning of experimental science. The fact that we worked at chemistry somehow got known at school, and, as it was an unprecedented fact, I was nicknamed "Gas." I was also once publicly rebuked by the head-master, Dr. Butler, for thus wasting my time on such useless subjects; and he called me, very unjustly, a *poco curante*, and, as I did not understand what he meant, it seemed to me a fearful reproach.

THOUGHT AND LANGUAGE.

By DANIEL GREENLEAF THOMPSON.

MODERN philosophers and psychologists have acknowledged in no equivocal terms the great debt which thought owes to language. They have unhesitatingly admitted that without language little progress could have been made in the development of the thinking powers and their product, knowledge. It has been conceded to be the principal expression of thought and feeling, and the chief means of communication between one mind and another. Many writers upon the science of mind have even deemed that, before proceeding to an examination of the mental powers and their exercises, some analysis of language as the supreme instrument of thought was a "necessary preliminary" (Mill's "Logic").

Notwithstanding these emphatic and cordial tributes to the importance of linguistic systems to the growth of intelligence, proceeding both from the Lockian and the Kantian side of philosophical debate, Professor F. Max Müller is not satisfied with the position thus accorded to language in its relations to psychological science. He comes forward to contend* that thought without language (or its

* "The Science of Thought." New York: Charles Scribner's Sons, 1887. 2 vols., pp. 325, 330. Price per vol., $2.

"No reason without language,
No language without reason."

equivalent embodiment) is not possible, that the science of the growth and development of language is the only true science of the growth and development of mind, and that "this revelation of the oneness of thought and language means a complete revolution in philosophy" (vol. i, p. 50).

It is not needful for us to speak of Professor Max Müller's right to be heard on any subject to which he devotes his attention, nor of his erudition, his agreeable literary style, the service he has rendered to science and literature, nor of the lovable personal character of the man. All these things everybody allows. Our purpose then, is—premising that "The Science of Thought" is full of interest, and displays, as usual in his books, the author's great philological learning—to examine the main thesis of the work; to determine, if possible, whether it is true, and, if so, whether or not it effects any "revolution in philosophy."

"The Science of Thought" is not a general psychological treatise. It is an adjunct to the science of language, to which it belongs, rather than to psychology. It is less expository than polemical, and the gist of the work is the argument to prove that thought (in the author's meaning of the term) depends absolutely upon language, and that the way to study the human mind is to study human language.

Of course, it is essential to note carefully in the first place the author's use of the term "thought." His book has aroused quite a controversy already, and a dozen or more letters on the subject have been published in "Nature," and reproduced in "The Open Court," of Chicago. They are from the pens of Francis Galton, the Duke of Argyll, Mr. Hyde Clark, Mr. T. Mellard Reade, George J. Romanes, and others, with replies by Professor Max Müller. They present various considerations to show the error of the latter, such as the cases of deaf-and-dumb people, sudden aphasia in disease, and the results of personal introspection. Mr. Galton in one of his letters charges that Professor Müller has not told the reader what he means by "thought," to which the author rather indignantly replies that the definition is found on his first page, which at least it is usual for reviewers of books to look at, if they go no farther. After so explicit a direction, we certainly shall not incur the reproach of saying that there is no such definition; but, in our judgment, the author would have succeeded better if he had left his definition more indefinite.

Professor Max Müller means by thought "the act of thinking," and by thinking "no more than combining." "I think, means the same as the Latin *cogito*, namely, *co-agito*, 'I bring together,' only with the proviso that bringing together or combining implies separating, for we can not combine two or many things without at the same time separating them from all the rest. Hobbes expressed the same truth long ago, when he said that all our thinking consisted in addition and subtraction." "Much, however, depends upon what we

combine and separate," and hence we must consider the material of our thoughts, "the elements which we bring together or co-agitate." These are sensations, percepts, concepts, and names. These, though distinguishable, never exist in reality as separate entities. "No words are possible without concepts, no concepts without percepts, no percepts without sensations." The author then attempts to show, in reverse order, that "sensations are impossible without percepts, and percepts without concepts, just as the cloth is impossible without the threads, and the threads without the wool." This made out to his satisfaction, the argument follows that concepts are impossible without words—hence percepts and sensations are impossible; and thus thinking is not possible without language.

It would be much easier to deal with Professor Müller's reasoning if it were not complicated by various qualifications of the above simple statements, which make his meaning somewhat doubtful. He declares in one place that "thoughts may exist without words, because other signs may take the place of words. Five fingers or five lines are quite sufficient to convey the concept of five between people speaking different languages, possibly between deaf-and-dumb people who speak no language at all." Thus, it seems, we are to consider language as consisting of other signs as well as words. This, however, is not to affect the general proposition. Again, the author does in his book concede that we can reason without words, but in his letter to Galton of May 15, 1887, he declares that this "is no more than reasoning without pronouncing words." It is "symbolic, abbreviated, or hushed language," which "presupposes the former existence of words." Moreover, in this same letter, he avers that "sensation, passions, and intuitive judgments . . . clearly require no words for their realization." He also implies that seeing, feeling, acting—all may take place without what he terms thinking. "Instantaneous and thoughtless action is often more successful than the slow results of reasoning." But without seeking for further illustration, enough has been noted to show that Professor Müller has not clearly and consistently developed his own doctrine.

If thinking is bringing together or combining, addition with its complementary subtraction, the question arises, whether we are to apply the term to the combining into unity which is necessary in every act of knowing, in order to make that presentation of an object to the subject which is cognition itself, or to that combination which we ordinarily designate by the term *association*. My eye rests upon a patch of color on the wall; the cognition of this as an object involves "co-agitation" or combining. Surely we are not asked to believe that the presentation of this to the mind as an integer, and the holding of the mind's attention upon it, is impossible without language! It can not be that this is thinking in Professor Müller's intended sense of the word. Rather, he means association. "The very moment we be-

come conscious of a percept, or of an individual object, we have to comprehend it under something else, and thus to begin to conceive it, even if it be under the most general categories of our mind. . . . Any green, as soon as it is perceived as this green, is *ipso facto* perceived as like unto other greens, and as unlike yellow and blue; it is conceived as something which we afterward call color." These words aim to express the natural process of association which occurs in every mind, indeed, and Professor Müller's chief point is that this can not take place without language.

Let us consider for a moment the author's division of the material or elements of thought into sensations, percepts, concepts, and names. The question is at once suggested, Why are not names, percepts? A name is certainly a word, or set of words, and a word is nothing to our intelligence except as brought or to be brought to our ear or eye by the ordinary processes of sensation, and perceived by our intelligence. We may, it is true, invent a word by our constructive activity, but it is at once objectified, and when communicated to others it is to them a percept. Whatever may be its offices besides, it is at least this. Its additional office is by itself, or in conjunction with other words, to constitute a name; and a name is a mark or a symbol, serving the double purpose to recall to ourselves some previous object of cognition, and to make it known to others. This is accomplished according to the laws of association and representation. Names, then, are certain symbolical percepts, which, by the processes of redintegration recall past experiences. Now, it is idle to say that word-percepts are essential to this course of mental operation; one green will recall another green without any word being needed. The picture of the Matterhorn before my eyes instantly brings back to me the Matterhorn as I saw it from the Riffel; this suggests the Breithorn, Monte Rosa, my view from the summit of the latter, and a whole train of personal recollections, just as infallibly and certainly as the word *Matterhorn*, which I find on the printed page. I do not deny that in the train first suggested words interpolate themselves; but I maintain that the picture of the Matterhorn reproduces in my mind the actual sight without need of the intervention of any name, and before the name occurs. Now, suppose that the picture be one of a mountain I have seen, but of which I do not recall the name. I remember at once the visual appearance; the words "mountain," "peak," "horn," "pic," "ice," etc., do not come to my mind, nor does any one of them nor any word or name. The sight I beheld is there, and then I try to think of the name of the mountain or the locality. So that if Professor Müller means to declare that we can not represent or associate ("combine or co-agitate") except by the use of language, intending by language articulate words, certainly universal experience negatives his assertion. But, if under language be included everything which recalls to the mind something else, his statement reduces itself to the proposition

that we can not think (that is, combine, associate) without mental objects to associate, and that every mental object is a portion of language. To assert this would not be a "revolution in philosophy," but we might properly call it a revolution in the science of language.

Let us now consider the formation of concepts or general notions upon which the author lays so much stress as supporting his theory. Professor Müller brings forward the doctrine of Locke, Berkeley, and Hume, that "a general is nothing but a particular idea annexed to a general term—that is, to a term from which a customary conjunction has a relation to many other particular ideas and readily recalls them in imagination." It can not be doubted that there is substantial truth in this statement, though it needs qualification, but it does not prove Professor Müller's point. There must, indeed, be a *fundamentum* in every general notion, a nucleus, a type, a symbol. When we have in our minds the general notion *horse*, we have some particular horse, either remembered or constructed in imagination from former experiences of horses. With this goes the cognition that there are other objects like this one. To elucidate, I may, perhaps, be permitted to quote from a former analysis of my own:* "Whatever association brings up the concept evokes the cognition of one or a small plural number of individuals which are either remembered as wholes or constructed out of remembered parts, and with which is associated the idea that there is a number of objects not definitely recalled which are similar to the individuals before the mind in the particulars characterizing the concept. . . . When we think of *man*, we remember a particular man, or imagine one; or the mind runs over the representations of several men, after which it rests content with the idea of an indefinite number of men about the same as those ideally presented." Now, the office of a name in such a connection is to furnish a connecting link in thought between a present cognition (or experience generally) and past ones. When I see a moving object in the distance, and as it comes nearer I identify it, I doubtless think by saying to myself, "It is a man." But if I see a strange creature, the likeness of which I had never seen but once before, and which, so far as I am concerned, is nameless, when I observe the second, the first is recalled, and identification takes place. This is just as much thought as if there were the intervention of a name. Suppose I see a third creature, which, by representative association, I class with the other two. Common characters are noticed, and I begin the formation of a general notion. This is completely done by the mere association of any striking resemblance, as a horn, a spotted skin, a peculiar howl, an odor. Any one of these peculiarities may form the nucleus or mark which will recall the creature, and knowledge of it can be communicated to others by gesture, by a picture, or by a word. Thought consists in identification and discrimination in present and past experiences, and between

* "A System of Psychology," Chapter I., Longmans, 1884.

the two. Predication is the expression of a judgment, and a judgment is a cognition of agreement or difference; this takes place constantly without language, which latter only facilitates the processes of association. Indeed, a little reflection will convince us that language itself is not logically possible without prior thought. For a word or a name only becomes such by a process of thinking. It must be first fixed by association before it begins to do duty. Before I cognize an object, as a horse, the term *horse* itself must have become associated with other objects which have come into experience. If the attaching of a word *horse*, a percept, to another percept—a horse actually seen, as the mark of the latter, is not thinking; then the association of the horse seen with the word *horse* established as a mark of past experiences can not be thinking, for the two processes are precisely the same. The truth is, that both processes are thought. We may freely admit a great deal that Professor Müller asserts; but when we follow out his own propositions to their proper sequences, we find that his thesis is only true on the hypothesis that *language and objects of cognition* are convertible terms. People ordinarily understand that language consists of articulate words. Communication of one mind with another may take place by gestures, facial expressions, contortions of the body, inarticulate sounds, or by simple touch. But none of these are properly language. Written words are symbolic of spoken words, which are themselves articulations of the voice, and, while the former perform the office of concentrating, recording, and perpetuating mental experiences, as do many other symbols, their essential character, as *language*, consists in their relation to articulate communication.

While our author declares himself to be an evolutionist in general, certainly in the science of language, he brings out as a prominent consequence of the truth of his theory of thought, the untruth of that particular doctrine, commonly known as the Darwinian—namely, that man is descended from lower forms of animal life. This Professor Müller asserts to be impossible; and the proof is that animals have no language or any capacity to form language. "If concepts are impossible without names, . . . we then have a right to say that the whole genus man possesses something—namely, language, of which no trace can be found even in the most highly-developed animal, and that therefore a genealogical descent of man from animal is impossible." It may be admitted freely that animals have sensations and percepts; they feel, they perceive, they remember, they act. But concepts they do not have. They are without the power of forming general notions. This is evidenced in the fact that they are without language, concepts being impossible without names. Now, it is quite obvious, to the casual reader even, that Professor Müller has destroyed his own argument on this point by his previous positions. For he takes considerable pains to prove that percepts are impossible without

concepts, and sensations without percepts. He maintains that no perception occurs without a generalizing movement. "All percepts are conceptual." This being so, what becomes of the claim that brutes, with feeling and ability to perceive, do not form concepts? And if, as the author reluctantly does in one place, we concede that perception may exist with only "incipient concepts," what should prevent the development of the generalizing power in successive individuals to the degree that it is found in the highest intelligence?

The considerations adduced by Professor Müller on the question of the origin of species, and the descent of man, present nothing, therefore, for the "Darwinian" to answer, except the fact that man has articulate language, and brutes do not have it. This fact has been allowed its full weight in the great discussions upon the descent of man, of which our limits will not permit us to give even a *résumé*. It is sufficient to remark that whatever strength may lie in the argument from this circumstance, its force is not great enough to countervail the many converging proofs of the Darwinian hypothesis; and, further, we may safely reiterate with Darwin that "the faculty of articulate speech in itself does not offer any insuperable objection to the belief that man has been developed from some lower animal." Indeed, the wonder is that Professor Müller's own philosophy of mind should not have caused him to see that the difference between the mind of the brute and the mind of man is one of degree, not of kind. He lays great stress on the unity of mental action. The mind is one in all its exercises. There is no sensation without perception, and so forth, as already instanced. If, then, he can not doubt that a lower animal has some intelligence, the inference must be that the essential characters of the other mental exercises are in the animal's intelligence, at least in embryo. We may believe that Professor Müller is right in much of what he says as to the unity of cognitive exercises. Attention to an object presented, association and representation, are the primary mental processes, and each is necessary to the other. Given these, all the products of thought that we designate by such terms as concepts, inferences, fictions, memories, are readily explicable and their relations to each other made manifest. The chief difference between the mind of man and that of the brute lies in the complexity of association and representation. Man's inferences reach farther, and his generalizations are higher, more complex, and more abstract. It is the same sort of difference which subsists between the intellectually cultivated man and the savage, though, of course, this difference is greater when we compare man with even the higher brutes. But in the latter the same processes are observable. They attend, they associate, they represent; they feel and they act; they have nervous systems; they have mental communication. I see no escape from the conclusion that they generalize, and I would not be at all surprised if it should some time happen that an ape be taught to use articulate language.

Much more might be remarked in refutation of Professor Müller's thesis, but I have probably already tired the reader's patience. I hope enough has been said to show that this learned author has not even brought out a clear and consistent statement of his own position, much less to have effected any "revolution in philosophy." I have not discussed his theory of the formation of roots in language, for such a discussion seems unnecessary after the examination thus far made into the nature of thought. Nor do I stop to consider his lament over the neglect of Kant among later English thinkers. I can see no evidence that Kant has been neglected or failed to receive the attention that is his due; but all this is quite irrelevant to Professor Müller's argument. As for the latter it is self-contradicted in his own book, and any thorough analysis of mental operations would, as seems to me, independently demonstrate its fallaciousness. Altogether, the impression made upon the reader of "The Science of Thought" is that of a work written by a man, who, possessed by his favorite science, endeavors to use it for the explanation of all other sciences without much reference to the results which an unbiased and dispassionate study of those sciences would yield.

Professor Müller informs us that his book was written for himself and for a few friends, with whom he has been traveling for many years on the same road. We are grateful for the permission to join this band of peripatetics for the while, and, if pressing duties elsewhere oblige us to part from them, we can cordially thank Professor Müller for a charming entertainment, reserving, of course, to ourselves that liberty, which all good society allows, of afterward abusing the company.

THE METALS OF ANCIENT CHALDEA.

By M. P. E. BERTHELOT.

IN the pursuit of my studies of the origins of alchemy and the metals of antiquity, I have had occasion to examine substances recovered from the Palace of Sargon at Khorsabad, and from the excavations made by M. de Sarzec at Tello, as they are preserved in the Museum of the Louvre. I intend to describe the results of my analyses, and then to examine a number of new or little-known documents relative to the origin of the tin used by the ancients in the manufacture of bronze.

In the course of his excavations, in 1854, M. Place discovered, under one of the angular stones of the Palace of Sargon, at Khorsabad, a stone chest containing votive tablets, covered with very clear cuneiform inscriptions commemorating the foundation of the building, B. C. 706. According to M. Place, there were five of these tablets; but the form of the inscriptions indicates that there were seven of

them, designated by names. Only four of them are in the Louvre Museum, the other three are lost. The four which are known bear long and detailed inscriptions, of which M. Oppert has published translations of three in M. Place's work on "Nineveh and Assyria." The sense is nearly the same in all the three, and relates to the construction of the palace. According to this translation, the tablets were of gold, silver, copper, and two other substances, the names of which have been identified with lead and tin—the last rather doubtfully, according to M. Oppert; and, lastly, of two additional substances, bearing the determinatives of stones employed as materials of construction, which are considered to be marble and alabaster. Unfortunately, the several tablets do not contain separately the name of the material of which they are made. I have examined the four tablets in the Louvre. They are rectangular, and a few millimetres in thickness. The golden plate is the thinnest, and may be easily recognized, although it has lost its brightness. It weighs about 167 grammes. It was shaped by hammering. The metal is not alloyed in any notable proportion. The silver plate is quite or nearly as pure. It is slightly blackened on the surface by the formation of a sulphuret, as usually happens to silver which has been exposed for a long time to atmospheric agencies. It weighs about 435 grammes.

I give these weights as matters of fact, without prepossession on the question of whether they corresponded with the relative values of the metals at the time of the foundation of the palace.

The plate supposed to be of copper is deeply altered and partly exfoliated by oxidation. It weighs, in its present condition, 952 grammes, which shows that its dimensions were considerably greater than those of the other two plates. Its color is a dark red, which is determined for the most part by the presence of the protoxide of copper. It is not pure copper, but bronze; a specimen, filed off from the edge, contained, by analysis, tin, 10·04; copper, 85·25; oxygen, etc., 4·71.

Neither lead nor zinc, nor any other metal, is found in noticeable quantity. The proportion of tin corresponds with that in golden-yellow bronze, but the presence of protoxide of copper has changed the color. This composition is also found in a large number of ancient bronzes; of which I will mention only an Egyptian mirror of the seventeenth or eighteenth century B. C., which I once analyzed for M. Mariette. It contained 9 parts of tin and 91 of copper.

The fourth tablet is the most interesting of all, on account of its composition. It weighs about 185 grammes. It is composed of a bright white substance, hard and opaque, carefully cut and polished. It had till now been thought to be of a metallic oxide, and had first been designated as the antimony tablet; others said tin, because it was thought to have been made of a metal which time had gradually oxidized. But neither antimony nor tin possesses the property of undergoing a change of this kind, especially when inclosed in a stone chest.

At most, lead and zinc are susceptible of being converted into oxide or carbonate in a moist medium; but under such conditions they are disintegrated and fall into dust, while the tablet is quite compact and covered with a very fine and extremely clear inscription. Its real nature was therefore a riddle. We then first carefully sounded it, and ascertained that there was no central metallic leaf in its thickness. Chemical analysis indicated that it was a pure, crystallized carbonate of magnesia—a substance that is more refractory to dilute acids and atmospheric agencies than carbonate of lime. The polishing of the tablet appeared to have been completed with the aid of an almost insensible trace of fatty matter, which manifested itself on calcination. We observe here that our magnesia and its salts were not known in antiquity and the middle ages, and that pure and crystallized carbonate of magnesia is a very rare mineral, and was not known by Haüy at the beginning of the present century. But in intimate association with carbonate of lime it constitutes *dolomite*, a very abundant rock. Carbonate of magnesia is found principally in veins intercalated in talcose schists, serpentine, and other magnesian silicates, where it results from the slow decomposition of the rocks by natural agencies. The material of the tablet in question also includes a few traces of silica, which indicate the same origin. The choice of so exceptional a mineral for the fabrication of a sacred tablet can not have been made by chance. It doubtless responded to some particular religious idea. At any rate, it proves that the Assyrians were acquainted with the carbonate of magnesia as a proper substance. To what word did this tablet correspond in the inscription, in which it appears to figure under the name of one of the supposed metals? Notwithstanding the absence of a special denomination on this tablet, M. Oppert believes that it was designated by the word *a-bar*, which had been supposed to mean tin. I thought it might be useful, in the effort to obtain new light in this matter, to analyze the substance of which the great bulls in the Louvre Museum are made, and see if it contained dolomite. The analysis determined, however, that this matter was a crystallized carbonate of lime representing the physical constitution of marble, or rather of that variety of limestone which was formerly confounded, under the name of alabaster, with anhydrous sulphate of lime.

While I was studying the tablets of Khorsabad, M. Heuzey called my attention to some metallic fragments of a vase and a votive figurine which came from M. de Sarzec's excavations at Tello. The fragment represents a portion of a cylindrical circular band which formed the mouth of a cast vase, and had been prepared by melting and casting. A part of the throat that separated this band from the body of the vase proper can still be seen. It is very simple in form, and without any inscription or even light delineation. The surface is covered with a very thin, yellowish-black patina. The mass is formed of a brilliant black metal, the fracture of which exhibits vo-

luminous, glittering crystals, of very hard but fragile material. On analysis it appeared to be nearly pure metallic antimony, containing no notable proportion either of copper, lead, bismuth, or zinc, but only some traces of iron. The patina was an oxysulphuret, which had been formed by the action of the traces of sulphureted hydrogen which exist in the atmosphere. The existence of such a fragment—of a cast vase of pure antimony—is singular, for this metal is not employed pure for any such use in modern industry, although it is often used in alloys; and I know of no similar example in the vessels either of the present or of past times. I had been told, however, that the Japanese used antimony in their manufactures, and I had been presented with a little winged dolphin which was supposed to be made of antimony. But the analysis of this dolphin showed that it was composed of zinc and other associated metals, and was far from being formed of pure antimony. If pure antimony has really been employed by the Japanese—which I doubt—there would have been a curious relation with ancient Chaldean customs.

An extremely curious circumstance, moreover, is the finding of this authentic manufactured fragment of antimony at Tello, a place which had been uninhabited since the time of the Parthians, and which contains the remains of the oldest Chaldean civilization. Antimony, in fact, is supposed not to have been known to the ancients, and not to have been discovered till toward the fifteenth century. Yet we find that the ancients were very well acquainted with our sulphuret of antimony, a natural mineral which they called *stibium* or *stimme*, and which they employed for many uses, particularly in medicine. A passage in Dioscorides, repeated by Pliny, leads me to believe that metallic antimony had been obtained in his time. We read, in short, in Dioscorides ("Materia Medica," book iv, chapter xcix): "This mineral is burned by placing it on coals and blowing them to incandescence; if the calcining is prolonged, it changes into lead (*μολυβδοῦται*)." Pliny says, likewise ("Hist. Nat.," book xxxiii, chapter xxxiv): "The calcining must be done with precaution, in order not to change it into lead (*ne plumbum fiat*)." These observations agree with phenomena well known to chemists. In fact, the calcining of sulphuret of antimony, particularly in the presence of charcoal, may easily bring it to the condition of fusible and metallic antimony, a substance which Pliny and his contemporaries confounded along with all other dark and easily fusible metals, with lead. The existence of the Tello vase proves that in Mesopotamia, likewise, and in probably a much more ancient age, they had tried to make cast vases with this supposed variety of lead, which was less liable to change than ordinary lead.

The metallic votive figurine of Tello suggests no less curious observations. It represents a divine personage, kneeling and holding a kind of metallic point or cone. It has engraved upon it the name of

Gudeah, a king who belongs to the most ancient age of which relics have yet been found in Mesopotamia—M. Oppert attributing to him an antiquity of four thousand years B. C. We are thus carried back to extremely remote times of metallurgical history. The figurine is covered with a thick, green patina, below which is a red layer, formed by the oxidation of the metal in the greater part of its thickness. Then comes a red metallic nucleus, having the appearance and tenacity of copper. It is the last remainder of the primitive metal, which has been progressively destroyed by natural actions. I have analyzed these different parts. The superficial green patina is a mixture of oxide of copper and a hydrated oxychloride of copper, the latter compound being known by mineralogists as *atakamite*. It is formed by the action on the metal of brackish waters, with which the figurine had been in contact, through the course of ages. The middle layer is a nearly pure protoxide of copper, free from notable quantities of tin, antimony, lead, or any similar metal. It results from a slow alteration of metallic copper. The nucleus was pure metallic copper.

The absence of any other metal than copper in this figurine deserves to be noticed. Objects of this kind are usually made with bronze, an alloy of tin and copper which is harder and more easily worked. The absence of tin from the Tello copper has a peculiar historical significance. Tin is much less diffused over the surface of the earth than copper, and its transportation has always been the object of a special commerce, in ancient days as well as in ours. In Asia, in particular, there had not till very lately been any deposits of tin found in any abundance except those of the Sunda Islands and the southern provinces of China. The transportation of this tin to Western Asia was formerly carried on by sea, to the Persian Gulf and the Red Sea, by long and arduous voyages; and it was carried thence to the coasts of the Mediterranean, where it came in competition with the tin of the British Isles which had been brought across Gaul, and with the less abundant deposits of Central Gaul, and, perhaps, also of Saxony and Bohemia. Voyages so long and arduous, and systems of navigation so difficult could not have been established till after many centuries of civilization. The Phœnicians, who had come from the borders of the Persian Gulf to those of the Mediterranean, seem to have been the first promoters of this navigation.

But I have recently become cognizant with two documents, which tend to fix a less distant origin for the tin of the bronzes of Assyria and Egypt. According to a note published by M. G. Bapst, a Russian traveler, M. Ogorodnikoff, was informed by the inhabitants of Meshed that there were at one hundred and twenty kilometres from that city, and at various places in Khorassan, mines of tin now worked. These statements should, however, be received with caution, on account of the uncertain quality of the oral declarations of Tartars. But it is a remarkable fact that they agree to some extent with a passage

in Strabo that has been pointed out to me by M. P. Tannery. Strabo (book xv, chapter xi, 10) mentions tin-mines in Drangiana, a region which corresponds with our Khorassan, below Herat, and toward the western boundaries of modern Afghanistan.

While tin is rare throughout the world, it is very different with copper, the ores of which are found at a great number of points. The mines of Sinai, not to mention more distant ones, were celebrated in ancient Egypt. The extraction of metallic copper from its ores is also easy. Reasoning from these facts, many archæologists have supposed that an age of pure copper, or an age in which arms and tools were made of this metal, preceded the bronze age. In order to judge the value of this hypothesis and determine the date at which this ancient navigation began, it would be necessary to possess the analyses of the most ancient objects to which a certain date can be fixed, among the remains of antiquity that have come down to us. According to analyses of this character, bronze existed in Egypt nearly two thousand years before the Christian era. The analysis of the figurine of Tello seems to indicate, on the other hand, that tin was not yet known at the time when that object was made, or that it had not yet been brought to the Persian Gulf. This is, however, only an induction, since some religious circumstance or another may have determined the exclusive employment of copper in the making of the figurine; and it would be necessary to examine many more objects and more various to reach certainty in that matter. It has, nevertheless, seemed to me that it would be interesting to indicate the problems of a general character that are raised by the analyses of the metals of Tello.—*Translated for the Popular Science Monthly from the Revue Scientifique.*

OUR FORESTRY-PROBLEM.*

By B. E. FERNOW,

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DOUBTLESS you have all seen, during the last ten years, numerous references in newspapers, magazines, etc., to the necessity of forest-preservation. This plea, however, even in this country, is not as novel and of as recent date as may be imagined. As far back as our colonial times, the fear of an exhaustion of lumber-supply alarmed New England legislators; and as early as 1801, the Massachusetts Society offered its prizes for timber-planting. We may smile over the fears of those times when railroads had not yet revolutionized methods of transportation, bringing the whole world under contribution for supplies. Yet, while those fears were premature, they were nevertheless prophetic, and the very railroads which have opened up the vast forest

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areas of the Northwest have brought rapidly near to us the possibility of a time when a scarcity of wood may be felt. For the haulage over so long distances of so bulky freight, in addition to other obstacles, allows only a small amount of the timber growing in those distant forests to be profitably moved to market, and from fifty to sixty per cent, often even more, of the trees cut is left in the woods to rot or to furnish food for the yearly conflagrations. Even now, in the more remote lumber-camps, any part of a tree less than one foot in diameter is considered unprofitable, and is left in the woods.

But while—as I will show farther on—the fear of those early alarmists is with renewed force, and upon a more reasonable basis, again pressed upon us, other considerations besides a waning lumber-supply compel our attention to forest-preservation. A vague idea that some connection existed between the forest-cover and the climatic conditions of a country has been prevalent from olden times. "The tree is the mother of the fountain," or "the father of the rain," are significant expressions of the sages of old. But it was due to the representations of such eminent naturalists as Humboldt, Boussingault, and Becquerel, that the important and complicated part which the forest plays in the economy of Nature was first clearly recognized. And now, in the light of recent scientific experiments and investigations, added to the historical evidence of earlier times, we are forced to consider the forests of a country in a fourfold aspect:

1. As furnishers of raw material.
2. As regulators of climatic conditions.
3. As regulators of hydrologic conditions, influencing the water-flow in springs, brooks, and rivers.
4. As regulators of soil-conditions.

I need not stop to call to your mind the endless variety of articles into which the product of the forest enters. There is hardly any manufacture, hardly any branch of human industry, in which wood does not find application in some way or other; and we can say, without exaggeration, that the progress of the human race in civilization has been largely dependent on this material. A continued supply of such an important substance must, then, be deemed a necessity. To the assertion that substitutes are being and will be easily found, I would reply that, with the invention of substitutes, new applications of wood are also invented; that with the growth of civilization the use of wood has grown disproportionately; and that the population of the earth is constantly increasing, so that substitutes would have to be found to meet a demand for wood by far greater than that of the present. Besides, if we can, by reasonably husbanding present supplies, and by exercise of management, prolong for the human race the use of this most convenient material, should we not rather curb our spendthrift tendencies than rely upon the ingenuity of our children in supplying substitutes?

The value of the forest as a producer gains additional significance in the economy of a nation from the fact that it yields a return on land which for other purposes may be useless. Timber is the crop which we can raise on our wastes and barrens, and which enriches and improves the soil instead of exhausting it. For the forest-tree generates most of its substance from the carbonic acid of the atmosphere through assimilation in the leaves, while from the soil it requires mainly water, most of which and of the exceedingly small amounts of mineral food that enter its composition, are derived from the deeper strata. The greater part of this mineral food is returned by the falling leaves to the surface of the soil, and thus that circulation of matter is set up which makes forest-growing a means of improving poor soils.

The prospects of private gain might seem to be sufficient to insure the raising of timber as well as of grain or vegetables to the full extent desirable. But against the advantages of the wood-crop just mentioned must be set certain drawbacks. The agricultural crop is produced in one year, during which it is easy, by constant cultivation, to keep up favorable conditions, and the expenditures yield their profit within a year's time. The forest-crop requires ten, twenty, forty, nay one hundred and more years to grow to useful size, does not admit of much aid on the part of the cultivator, and must have the favorable conditions for its development provided in the methods by which it is originated. It not only requires a greater amount of capital, but a greater amount of foresight, to carry on a systematic forestry with similar objects in view to those of systematic agriculture.

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Here, however, enters the *national* interest in the business of forestry, based upon the indirect significance of the forest, namely, its influence on climate, water-flow, and soil. Even in ancient times this significance was vaguely realized, when Critias spoke of the "sickness of the country in consequence of deforestation." The earliest written expression which ascribes to the forest a definite influence upon climatic conditions we owe to the Spaniard, Fernando Colon (about the year 1540), when he states that, "on Madeira, and the Azores and Canary Islands, the rains have become rarer since the trees, which spread their shade, were cut down." In later times we find similar observations and allusions to this connection between forests and climatic or agricultural conditions in the literature of almost all civilized nations.

But these occasional notes assumed a practical significance only when, after the extensive clearings which were perpetrated by an unbridled populace during the French Revolution, the injurious consequences upon some of the most fertile districts of France made themselves felt, when fields and pastures which had sustained a thrifty and prosperous population were turned into sand-wastes or made sterile by torrential action of mountain-streams, carrying away the fertile

soil, and substituting *débris* and unfertile ground from the mountains, and pauperizing the once productive lands, inflicting damages, which now, by the expenditure of millions of dollars yearly, and with the exercise of the greatest ingenuity, can hardly be repaired. Within the last twenty years, France has reforested about two hundred and fifty thousand acres of mountain-lands, at a cost of $30,000,000 of which the Government paid one half, the local communities the other half. In addition, two hundred thousand acres of sand-dunes, which were the result of injudicious clearing, have been reforested since 1862, and thus been made productive.

An extensive literature on the subject of forest benefits has now accumulated. But I do not intend to rehearse these often-cited arguments, which are so well elaborated in George P. Marsh's classical book, "The Earth as modified by Man." We must admit, however, that historical evidence alone can not be held sufficient proof of any natural law, and a problem of natural science needs for its solution to be subjected to scientific methods of investigation and reasoning. This has only lately been done with regard to forest influences; and, though systematic and continuous observations have not yet extended over a long period, we are already prepared at least to understand the character, though not always the extent, of the part which the forest plays in the economy of Nature. We have learned to discriminate between the different functions of forest influences. We have learned that the mechanical influence of forest-cover upon hydrologic and soil conditions is undeniable; we have learned that climatic changes due to deforestation may be favorable as well as unfavorable; that the great characteristics of a climate, due to cosmic conditions, such as the twofold movement of the earth, the presence of water-surfaces, elevation, the prevailing winds, etc., are probably beyond the reach of forest influence; that such influence must, in the main, be local, and its nature and extent be dependent largely upon the geography of the locality.

The *rationale* of forest influences is easily enough understood, if we consider them step by step. The climate of a locality—i. e., the interdependent oscillations of temperature and humidity of the air (not as it is popularly expressed the *mean* condition of these factors)—is, in the first place, dependent upon the heating effect of the sun's rays; in one word, upon "insolation." The temperature of the air derives its heat, for the most part, only from contact with the heated earth or objects on the earth, and by radiation from these. Any mechanical barrier, then, against insolation of the soil, like a shady, dense forest, must have the effect of lowering the temperature of the soil and consequently of the air above it. The immediate consequence of this is diminished evaporation from the surface of the soil; while, on the other hand, the transpiration through the leaves makes the ground-water of greater depths available to the atmosphere. Thus cooler and

moister air is found within and above the forest, which is communicated to the surroundings, and tends to bring to condensation any passing clouds, which the hot air ascending from the open field would have prevented. In this manner the forest acts exactly like a large sheet of water, as a starting-point of local winds, by which the characteristic features of the forest climate—i. e., shorter range of thermometrical extremes, and greater humidity—are communicated to the surroundings. Yet, whether under all circumstances, a direct increase of precipitation over surrounding areas may be produced through forest influence remains still unproved, and appreciable effects can only be expected from dense and extensive forest areas.

The influence of a mechanical barrier against chilling northern and hot southern blasts, such as even a simple wind-break of two or three rows of trees can produce, is well known to the prairie settler. But by far the most important function of the forest lies in the preservation of soil-humidity and in the storage and equable distribution of the water capital of the earth. The moss and leaf-mold act as a sponge, taking up all the atmospheric water which reaches them, and only gradually give up the same to the soil, from which it reappears as springs, brooks, and rivulets, forming the great water reservoir of agricultural lands, giving up its accumulations gradually throughout the season when most needed. While this beneficial action is especially noticeable in the mountainous regions, the forest of the plains acts also as a regulator of hydrologic conditions, as is apparent from the observation that on deforested areas the ground-water level sinks and aridity increases. While the large floods are probably, to a great extent, due to cosmic causes, yet it can not be denied that the deforestations at head-waters of streams must have aggravated the evil, and that local floods and their concomitants, namely, washing away of soil, pauperizing fertile valleys, etc., can be obviated by proper forestry, has been practically demonstrated by the reforestation in France and the Tyrol. On the paramount importance of the proper utilization of the water capital of the world, a volume might be written. Suffice it to say, that our agricultural development, and with it our civilization, depends upon it.

Lastly, I should recite the sanitary effects of the forest, the investigation of which has, of late, brought many important and interesting results. That the activity of individual trees in assimilating carbonic acid and exhaling oxygen improves the air we breathe has been long a recognized fact, and the healthfulness of forest air is therefore generally conceded. It is asserted that, by deforestation, malarial districts have been created, while, on the other hand, the planting of eucalyptus and other trees is said to have produced the opposite effect. It is quite possible that the manifold ramifications of the crowns of the forest act as a kind of filter in purifying the air of the spores of fungi and bacteria, thus diminishing the danger of epidemics, etc.

To dwell on the æsthetic aspect of the forestry question would lead me too far, though its effect upon national life should not be underestimated, and deserves fully our attention.

From this hurried review of the relation which the forest-cover of the earth holds toward the economies of Nature, it should appear that more than a private interest must attach to it; that, wherever men are aggregated as a nation or a government for the protection of the public against the willfulness of the few, the care of the forest should receive earnest and timely consideration, and, if necessary, legislative action.

The forestry-problem, then, exists because of the dependence of favorable agricultural conditions upon the existence, proper management, and location of forests, and because the common interest of the nation in the maintenance of such conditions does not find a responsive appreciation on the part of those private citizens who own the forests, and who refuse to be restricted in the exercise of their free-will and their property rights in respect to them, though they suffer a number of other interferences imposed for the common good without grumbling. The forestry-problem is, to reconcile and adjust these opposing interests, and, either by persuasion or coercion, to insure the preservation and the conservative management of forest areas whose devastation would injure the interests of the whole community, and also to encourage the creation of new forest areas where needed.

Let us now ask, How far are we concerned in this forestry-problem in this country at the present time? Is the condition of our forests, in comparison with our present and future demands upon them, such as to make the immediate consideration and speedy solution of the problem a necessity? Has the time arrived for us when the needs of the future should be considered in our actions in the present?

First, in regard to material supplies: it is a most difficult task to arrive at precise data from which to judge as to supplies at hand; and still more difficult, if not impossible, to predict exhaustion or the time of scarcity. The way of speaking on this aspect of the question has, by necessity, been without proper basis. The vast stretches of so-called forest still standing encouraged the notion that exhaustion was impossible—that Nature's provisions would, unaided, recuperate the drains made upon her. "Anyhow, there are a good many years' supplies ahead." Supplies of what, and for what demands? It is evident that we should discern, for instance, between building-timber supplies and hard-wood supplies, which latter, for useful purposes, are reproduced by Nature more easily and in shorter time. Unfortunately, we lack sufficient data to make any such discrimination; but we know tolerably well that the "inexhaustible" white-pine forests of the Northwest, which have supplied the bulk of our building material, will practically be exhausted in a very few years. The hemlock is soon to follow. We hear it stated that the capacity of the Northern

mills, which have depleted, in less than fifty years, a crop which it takes one hundred and fifty years to replace, is sufficient to rob the immense forest areas of the South of their valuable timber in very much less than twenty-five years—timber which it has taken one hundred and fifty to two hundred and fifty years to grow; and, though almost inconceivable quantities of standing timber are reported from the Pacific coast, even with the utmost stretch of the imagination, considering the wasteful manner in which that supply is being consumed, there can not be a sufficient supply standing to meet the present requirements of the whole nation for fifty years.

It is a most farcical attempt at deception which has been practiced in comparing the supplies of one particular region with the present requirements of that region. We are one country, one nation; and, unless we build Chinese walls around our different sections, the resources of the entire country must be placed in comparison with the requirements of the entire country. The only rational way of looking at the requirements and supplies of a large continental nation like ours seems to me the following: According to latest estimates, we consume yearly, with our present population of sixty million, not less than twenty billion cubic feet of wood. This amount is made up, in round figures, in the following manner:

2,500,000,000 feet for lumber-market and wood-manufactures;
360,000,000 feet for railroad construction;
250,000,000 feet for charcoal;
500,000,000 feet for fence material, etc.;
17,500,000,000 feet for fuel.

To this it will be safe to add, for wasteful practices and for the destruction by yearly conflagrations, at the least, twenty-five per cent.

The average yearly growth of wood per acre in the well-stocked and well-cared-for forests of Germany has been computed at fifty cubic feet. Applying this figure to our present requirements, we should have an area of not less than five hundred million acres in well-stocked forest to give us a continual supply of all kinds for our present needs. Now, a careful canvass made four years ago developed the result that the existing forest area in the United States, excluding Alaska and Indian Territory, comprised almost five hundred million acres (489,280,000); but it is well known to everybody who is acquainted with our forests that they can not compare in yield with the average European continental forests under systematic management. Much of what is reported as forest is useless brush-land, or open woods, and depreciated in its capacity for wood-production by annual fires, by which the physical structure of the leaf-mold is destroyed, and thus, too, its capacity for storing the needful moisture, reducing wood-production, and killing all young growth.

Without care, without management, and left to the kind but uneconomical work of Nature, interfered with, in addition, by rude and

ignorant action of man, it is doubtful whether, on the existing area, one half the amount of wood is produced yearly which we now require. We have, therefore, beyond doubt, reached—if not passed—the time when increased drain means squandering of capital, and when regard to husbanding, to careful management, to recuperation of our forests, and planting of new forests is required for the purpose of merely furnishing raw material; and it should not be forgotten that to reproduce the quick-growing white pine of an acceptable quality and sufficient size, requires not less than eighty to one hundred years, and for the long-leaved pine two hundred years; that, altogether, wood-crops are slow crops; that nothing of size can be grown under a quarter of a century at the best.

That this is a business requiring intelligent national consideration is apparent; not less so if we appreciate the magnitude of the values resulting from it. The total value of forest products in the census year was placed at $700,000,000, or ten times the value of the gold and silver production, five times the value of all coal and mineral production, and exceeding every one of the agricultural crops, corn and wheat not excepted; and representing in value about thirty per cent of the total agricultural production.

Turning to our concern in the climatic aspects of the forestry question, I have recorded my skepticism as regards a wide-reaching forest influence upon the climate of a country; and since the influence can only be local, since its nature and scope depend on geographical position, configuration, elevation, the neighborhood of large water surfaces, and prevailing winds, etc., it is evident that it is entirely impossible to speak of a safe percentage of forest-cover for a continental country like ours. The climatic factors at work and the requirement of regulating influences on the Atlantic shore have no bearing on considerations of the Pacific, and what the treeless plains need may not be needed by the lake-bordered States. A proportion of forest which has been suggested as safe, without any proper basis, however, is twenty-five per cent.

In order to study the need of considering forest climatic influences, I have divided the country roughly, as far as our scanty forest statistics permit, into eight or ten regions, or rather grouped the States together, which are more or less similarly situated as regards possible climatic influences of a cosmic nature. These groups are, to some extent, arbitrary, and, being based upon political divisions, for which alone approximate forest statistics exist, can not closely correspond to the range of actual climatic conditions. It would appear, however, that the Atlantic States, with over forty-three per cent of forest, as well as the Gulf and central Southern States, and even the lake-bordered Northern lumbering States, with nearly fifty per cent of forest-cover, can not, in general, be said to have gone below that safe proportion for climatic considerations; though in special localities the inroads may have been severe enough to produce undesirable results. But the

agricultural States—Ohio, Indiana, and Illinois, with 14·7 per cent; the Prairie States, with a continental climate, and with only 4·4 per cent; Texas, with 23·2 per cent, all in one corner; the Rocky Mountain States, with 14·1 per cent of forest-land, and their water-supply depending on the forest-cover; the Pacific slope States, though heavily timbered on the Northwestern coast, with 34 per cent, and in the southern and interior parts largely dependent on irrigation—*these*, I may say, come nearer to that lowest limit of forest-cover which is claimed as desirable for climatic considerations. Especially where the forest had been destroyed, and the climate made unfavorable before the advent of the white man, in the vast prairies, reforestation is demanded for purely climatic amelioration.

This has been recognized by the prairie settlers, tree-planting in shelter-belts and small groves has been begun, and the change for the better, aided by the breaking of the soil in large areas, is gratefully acknowledged. But a radical change in the inclement climate of those plains we can expect only from extensive and densely shaded forest-belts, dispersed over the country, such as only entire communities, or citizens aggregated in a government, will be able to provide.

Of injuries wrought locally by the reckless clearing of hill-sides and of deterioration of the soil due to inconsiderate action of man, I could entertain you by the hour; the country is full of examples. Any one who wishes to study the effect of such denuding of hill-sides upon the soil, the water-flow, and agricultural conditions, need not go to France, Spain, Italy, Greece, or Palestine. The Adirondack Mountains are within easier reach, where the thin cover of earth exposed to the washing rains is carried into the rivers, leaving behind a bare, forbidding rock and desolation, while at Albany the Hudson River is being made unnavigable by the *débris* and soil carried down the river; the Government has spent more than ten million dollars, I believe, and spends every year a goodly sum, to open out a passage over the sand-bar thus formed.

Go to the eastern Rocky Mountains, or to Southern California, and you can gain an insight into the significance of regulated water-supply for the agriculture below, and also learn how imprudently we have acted and are acting upon the knowledge of this significance by allowing the destruction of mountain-forests in the most reckless and unprofitable manner. Along the shores of Lake Michigan, and along the sea-coast, we are creating shifting sands by the removal of the forest-cover, to make work for the ingenuity of our children in devising methods for fixing these sands again. The vegetable mold with which the kind forest had covered the alluvial sands of the Southern coast-plain we are taking pains to burn off in order to replace it with expensive artificial fertilizers.

That the great flood of the Ohio, which cost the country more than twenty million dollars, was entirely due to deforestation, I will not

assert, but it must have been considerably aggravated by the accumulation of minor local floods due to the well-known reckless clearing of the hill-sides, which sent their waters down into the river in torrents. At the season, when the winter snows are melting, watch the newspapers, and you will find an almost daily mention of the disastrous ravages of brooks and streams, many of which injuries could have been prevented by avoiding the creation of their distant and indirect cause. Thus we may multiply examples all over the country, showing harmful local influences upon agricultural conditions due to forest devastation.

That the vast stretches of land in the Northwest, from which the white pine has been cut and burned off, present the aspect of a desolation which sickens the heart, you may hear from every one who has seen these deserts unnecessarily wrought by man. Every traveler in this country, be it to the White Mountains, to the Adirondacks, along the Alleghany Mountains; be it through the Rockies or the redwoods of California, can not but be startled by the desolate, sad aspect of many of these once beautifully-clad mountain-crests.

And we are a nation hardly a hundred years old, with over thirty acres per capita to spread ourselves upon. What will become of us, when we must live upon five acres per head? We are far enough advanced in our recklessness of disregarding the indirect significance of forest areas to have learned a lesson at home, and to feel the necessity of being more careful in the utilization of the forest, so as not to lose its protection for our agricultural and general interests.

While we have seen that all aspects, in which the forest must be considered, from the standpoint of national economy, show our conditions to be such as to call for solicitous consideration and action; this is still more apparent, if we analyze the difficulties to be overcome. These are much greater, in our case, than those encountered by any of the European nations. For abroad, government is so regarded as to give wider scope to its action, and not only are government forests and government forestry permissible and natural, but government interference, if for the interest of the general welfare, is borne less impatiently. Besides, forest management by these nations has been gradually led up to by an interest outside of forestry proper—the protection of the chase, which was fostered by the king, and then by nobles, on entailed estates, so that to the present generation a nucleus of forests has been preserved, upon which to expend the needful care and management.

Our difficulties lie mainly in the unique manner in which our country has been settled, and in the spirit of our institutions, which is too prone to resent interference with private rights, even where the common interest seems to call for such. The rapid development of railroad facilities has brought a whole vast continent within easy reach of market, and has allowed a population of only sixty million people

to spread itself over more than three million square miles of territory. In consequence, the necessity, or even desirability, for economical use of our resources can hardly be realized. The necessity of clearing woodlands for agricultural purposes, without a market for the timber, has bred a spirit of wastefulness in regard to that material; and this has been fed by the seeming inexhaustibility of existing natural supplies. The vast expanse of our country, with its endless possibilities and opportunities, has produced a tendency of instability and speculation—a tendency inimical to a business whose profits lie so remote as in forestry, and which presupposes a concern in the future conditions and welfare of a given locality.

Add to this the difficulty, over our vast and sparsely-settled country, of guarding forest property against theft and fire, which invites the owner to cut and realize as fast as possible upon his holdings, and deters him from risking any expense on management; further, add that, as long as natural supplies can be brought to market from distant regions, and at prices far below the cost of their production—and all financial incentive to apply systematic forestry is wanting. While thus the ruthless slashing of the primeval forests goes on without regard to future or consequences, the comparatively insignificant beginnings of new plantations in the treeless plains can hardly be considered an attempt at compensation. Time, of course, would cure many of these unfavorable conditions; but meanwhile we are increasing the dangers of deforestation, and are preparing for those who come after us hardships which we could and should avert. How, in spite of the difficulties that oppose a systematic forestry, to insure a continuous and sufficient supply of raw material, and to preserve the favorable conditions which depend on proper forest areas—that is the forestry-problem.

The means for its solution I may only briefly indicate: they are education, example, encouragement, legislation. Some of these are of slow effect; others can be made to give results at once. Let the United States Government, which still holds some seventy million acres of the people's land in forests, mostly on the Western mountains, where its preservation is most urgently needed—let the Government set aside these otherwise valueless lands, and manage them as a national forest domain, and then the first effective step, a feasible and not a forcible one, is made. Let the military reservations on the Western treeless plains, which are still in the hands of the General Government, be planted to forests and managed as such; this would be no doubtful experiment, would interfere with nobody, would enhance the value of the surrounding country—and education, example, and encouragement are provided, as far as it is in the legitimate province of the General Government. And such example, instead of costing anything to the country, can be made self-sustaining—nay, productive—and would add appreciably to the people's wealth.

I have avoided introducing any sentiment in the treatment of this question, simply presenting its bearing upon a tangible basis; but it is, indeed, a question into the discussion of which sentiment of the highest order should enter; a problem in the solution of which we should be actuated by the grandest conceptions of our duty as citizens of this nation, as citizens of this world, with the solemn creed of one of our great naturalists (Frederick von Müller) before us:

"I regard the forests as a heritage given us by Nature, not for spoil or to devastate, but to be wisely used, reverently honored, and carefully maintained. I regard the forests as a gift intrusted to any of us only for transient care during a short space of time, to be surrendered to posterity again as an unimpaired property, with the increased riches and augmented blessings, to pass, as a sacred patrimony, from generation to generation."

THE DANGERS OF RECEIVERSHIPS.

By H. W. BARTOL.

PERHAPS no question of the day is exercising a more important influence on the investments of the country than this question of receiverships, and certainly none is of more importance to the investor in corporation securities, whether it be in their stocks or bonds; for, with the present readiness of our courts to appoint receivers on the slightest excuse, and to hold the properties indefinitely, no one can tell when his property may be taken out of his hands, nor, when so taken, how it will be administered. In fact, this readiness of the courts to appoint receivers, is taken advantage of to wreck corporations in the interest of one class of creditors to the injury of all others, and under it unscrupulous speculators have and are to-day using the mantle of justice to accomplish their ends.

But, as mere assertions prove nothing, it is the purpose of this article to review some of the results that have been reached by this means, not from the standpoint of a lawyer, but from that of a citizen, who has had some experience in this line. It is the view of the writer that the only excuse for a court stepping in to prevent creditors from enforcing their rights is that, *pending litigation to close up a corporation* and determine the exact rights of all creditors, the law will appoint receivers to conserve the property; in other words, the court will conserve the property as a whole, until it can determine just what are the rights and equities of all parties concerned, and then make a distribution accordingly, unless in the mean time the corporation shall be shown to be solvent. In the case of an assignee taking possession of an insolvent estate, the law prevents creditors from selling the property piecemeal, making it the duty of the assignee to dispose of it and

distribute the proceeds equitably; in fact, he may, with propriety go further: for instance, if part of the property in his charge was a warehouse, stored with goods, from which the roof were blown, there is no doubt he would be sustained in using funds in his hands to put on a new roof, as it is self-evident that such an expenditure is for the benefit of the creditors. The court may, if part of the estate is a factory filled with partly-finished goods, go further, and authorize the assignee to finish the same. But what would be thought of the assignee who went beyond this; who used the funds in his hands not only to mend roofs and finish goods, but to build new mills; who paid interest to some creditors and refused others; who, in a word, treated the property as though it were his own? Would he not be brought up with a sharp turn, and either displaced or made distinctly to understand that he was exceeding his authority, and would be held personally responsible? And are not the duties of an assignee, and that of a court taking possession of an insolvent estate, essentially the same? I think they are, and that our courts in the license they have allowed their officers, the receivers, have gradually but surely been drifting away from both the law and equity.

It is held that receivers' certificates are a lien preceding all mortgages, and were receivers restricted to the lines I have laid down, there would be some plausibility in the argument, as, if the money so raised were only used for what is absolutely essential to *conserve* the property, and is manifestly for the benefit of all, it may be just that all should bear the burden. But even this is an open question, as, what might be essential to a junior creditor, may not be so to one at the head of the line. For instance, in the case of a railroad, with a first mortgage of $5,000,000, and subsequent mortgages amounting to more than $100,000,000, it can hardly be claimed that the $5,000,000 would be imperiled were even so essential a thing as a bridge left unbuilt if it fell down, as it is plain, if the court use proper diligence in deciding the case, a decision must be reached, and a sale had before their margin of safety is gone, and by consequence it would seem but justice that receivers' certificates should only take rank as a lien *preceding the class of creditors who ask for the appointment of receivers;* and that this would work no hardship is self-evident, as, if those certificates were not marketable and the work really essential, the next preceding class of creditors would, in their own interest, make the application; it is true that the answer to this is that the trustees of all preceding mortgages are sometimes (perhaps always) notified of the application for permission to issue certificates, and that if they, as the official representatives of the mortgagees, do not object, the court has a right to suppose there is no objection to the certificates becoming a lien preceding their mortgages; and while this is technically true, still it is unfortunately a fact that the average trustee will not act until compelled to do so by the bondholders, and frequently the first the latter

know of the application is, that the certificates are issued and the damage done.

The next point to which I wish to call attention is the facility with which mortgage creditors may be injured by receiverships as at present conducted. For instance, in a large corporation in Pennsylvania, which had been for years in the hands of receivers, only going out of the custody of the court for a few months, to again return to it, the first set of receivers used the earnings of the company to purchase rolling-stock, which, when they were discharged, should have belonged to the company, but which, by a species of sophistication more legal than equitable, they managed to place in a car-trust, and when the court again took charge, the new receivers began their duties by issuing several millions of certificates, much of which money was used to pay debts contracted during the very few months the property was out of the hands of the court; and while these certificates are claimed to be a lien, ahead of the mortgages, some of this property was real estate which the mortgages did not cover.

Now, as regards the consistency of receivers, this very same corporation furnished a striking example, viz.: when the receivers first took charge, they insisted, despite many protests, on doing the following things:

1. Paying part of the principal and all of the interest on the floating debt.

2. Paying the guarantees on leased lines.

In reference to item No. 1, after much work, caused largely by the active opposition of the receivers, the court was persuaded to order that nothing should be paid on the principal, but allowed the continuance of payments of interest, the result being that a man who loaned the company, say, fifty per cent on its fifth mortgage, got his interest, while the holder of the first mortgage of the company would go without, and the holders of the subsequent mortgages get nothing, and have millions of coupons piled up ahead of them; and in this connection it would be well to take note of the peculiar preference our courts give to creditors who loan on collateral security, paying them interest when all others are refused, and allowing them to sell, no matter at what sacrifice to the debtor, the collaterals in their hands, while other creditors with equal if not superior rights are not allowed to enforce theirs.

In reference to item No. 2, we find these same receivers coming into court and protesting that they must pay the rentals of leased lines, no matter who suffers, and the next year not only refusing to pay some of these rentals, but, in some cases, asking permission to abandon the lines altogether.

But perhaps the most startling anomaly will be found in the case of two large corporations, one in Pennsylvania and the other in New Jersey, and both in the hands of the same court, where we find the

receivers, in one instance, paying the interest on all their bonds, and neglecting to pay the over-due principal on their car-trusts, while the other company defaults on all its bonds, and pays both principal and interest of its car-trusts. One of these decisions is probably right, but it does not require a lawyer to decide that both can not be, especially as in both cases the officials testified that the equipment was essential to its operation. Then, again, for some reason or other—probably that their jurisdiction extends over more than one State—most of the applications for receivers are made in the United States courts, perhaps, as in a recent instance, on the application of a man to whom the company owe a few thousands, when we have the ridiculous condition of affairs that those owning millions of the property, and even the trustees of the mortgages, have no legal status before the tribunal that is managing their property, because they, being citizens of the State in which the company has its domicile, have no standing in a Federal court, and, even did they have such standing, it is extremely difficult to get a court to find fault with or dismiss a receiver, firstly, because the receiver, being in possession of the books, it is difficult to get the evidence to show incapacity or misdoing, and, secondly, because for the court to do so would be to admit that it had erred in selecting the receiver, which courts, being human, do not like to do.

There is another danger about receiverships, viz.: if receivers are allowed to pay interest on floating debt, and continue payments to guaranteed and leased lines while defaulting on the securities of their own company, it can readily be seen that no better means could well be devised for unscrupulous men to wreck corporations, as all they have to do is to get themselves elected directors, make a few bad leases, loan the company's money to make gaudy reports until they sell their stock; then apply for a receiver, continue to pay the leased lines, until they freeze everybody out, and then, when they have bought in the securities at their own figures, sell out the property, and thus cancel the bad leases. Unfortunately, just this practice is the one by which some of the largest fortunes of the day have been made, and that it is well understood, the following remark of a prominent Wall Street operator will show, who said to a bondholder of a company that was in the hands of a receiver, "If you don't let us reorganize this property to suit the stockholders, we will keep it in the hands of the court for seven years!" If the court managed it well and fairly to all interests, the threat would have amounted to nothing; but, as some years of experience had shown just the contrary, it was a serious matter, and the bondholders had to yield, feeling that the terms, hard and unjust as they were, were preferable to further management by the court.

It will probably be asked, What is the cure for these troubles? which I confess is not so easy to answer; but I think the adoption of the following would go far to help matters:

1. Receivers' certificates should only take rank as a lien preceding the class of creditors on whose app'ication the receivers are appointed, and should *only* be issued to raise money to conserve the property, and *not for betterments.*

2. As soon as receivers are appointed, the court should call a meeting of the mortgage creditors, to learn if the receiver selected is satisfactory.

3. The court should see that all proceedings under which receivers are appointed are prosecuted to an end with the utmost diligence, and, failing this, at once discharge the receivers.

4. As it is evident that our courts, as at present constituted, have neither the time nor the ability to manage large corporations, and hence must rely on their officers, the receivers, there should be a new court, part of whose judges should be business men, to whom all such applications should be made.

5. The protection of this court should extend to collaterals of the insolvent debtor which are pledged for loans, as there is no good reason why this class of creditors should be allowed to sacrifice the property of the debtor when all others are stopped.

It is not intended in this article to reflect on the judiciary, who probably have done the best they could under circumstances really foreign to their training and duties, and who have naturally left matters pretty much to their officers, the receivers; nor is it meant to imply that, in some cases, the timely protection of the court has not been of great advantage to the creditors; but when, as in the case of the Logansport, Crawfordsville, and Southwestern Railroad Company, we see the first-mortgage bondholders deprived of the management of their property, and it so loaded with receivers' certificates that when it is sold they swallow up every cent; when, as in the case of the Vicksburg and Meridian Railroad Company, we find the receiver not only buying new rails, but changing the gauge of the whole line; when, in cases nearer home, we find receivers using the bondholders' money to pay leased lines, and issuing car-trusts to increase the equipment, is it not time to call a halt, and ask both the courts and the people to consider what they are doing?

General Tillo has pointed out, in "Petermann's Mittheilungen," how the idea of a great world-water-parting may be worked out from a consideration of the earth's surface. He has laid down on a polar projection-map, showing both the Old and New World Continents, in illustration of his proposition, a single continuous line, broken only by Bering Strait, extending from the south point of America north along the west side of South and North America, in an irregular diagonal across Asia to the Isthmus of Suez, and down Eastern Africa to the Cape. General Tillo, however, admits that there are special continental water-partings which do not quite conform to the line of the great parting, although, as a matter of fact, nearly all the great rivers of the world are divided by this parting into two directions.

A GREAT LESSON.

By the DUKE OF ARGYLL.

THE most delightful of all Mr. Darwin's works is the first he ever wrote. It is his "Journal" as the Naturalist of H. M. S. Beagle in her exploring voyage round the world from the beginning of 1832 to nearly the end of 1836. It was published in 1842, and a later edition appeared in 1845. Celebrated as this book once was, few probably read it now. Yet in many respects it exhibits Darwin at his best, and if we are ever inclined to rest our opinions upon authority, and to accept without doubt what a remarkable man has taught, I do not know any work better calculated to inspire confidence than Darwin's "Journal." It records the observations of a mind singularly candid and unprejudiced—fixing upon Nature a gaze keen, penetrating, and curious, but yet cautious, reflective, and almost reverent. The thought of how little we know—of how much there is to be known, and of how hardly we can learn it—is the thought which inspires the narrative as with an abiding presence. There is, too, an intense love of Nature and an intense admiration of it, the expression of which is carefully restrained and measured, but which seems often to overflow the limits which are self-imposed. And when man, the highest work of Nature, but not always its happiest or its best, comes across his path, Darwin's observations are always noble. "A kindly man moving among his kind" seems to express his spirit. He appreciates every high calling, every good work, however far removed it may be from that to which he was himself devoted. His language about the missionaries of Christianity is a signal example, in striking contrast with the too common language of lesser men. His indignant denunciation of slavery presents the same high characteristics of a mind eminently gentle and humane. In following him we feel that not merely the intellectual but the moral atmosphere in which we move is high and pure. And then, besides these great recommendations, there is another which must not be overlooked. We have Darwin here before he was a Darwinian. He embarked on that famous voyage with no preconceived theories to maintain. Yet he was the grandson of Dr. Erasmus Darwin—a man very famous in his day, who was the earliest popular exponent of evolution as explaining the creative work, and who, both in prose and verse, had made it familiar as at least a dream and a poetic speculation. Charles Darwin in his "Journal" seems as unconscious of that speculation as if he had never heard of it, or was as desirous to forget it as if he concurred in the ridicule of it which had amused the readers of the "Anti-Jacobin." Only once in the "Journal" is there any allusion to such speculations, and then only to the form in which they had been more scientifically clothed by the French naturalist La-

marck. This is all the more curious and interesting, since here and there Charles Darwin records some facts, and enters upon some reasoning, in which we can now see the undeveloped germs of the theory which ultimately took entire possession of his mind. But that theory was, beyond all question, the later growth of independent observation and of independent thought. He started free—free at least, so far as his own consciousness was concerned. The attitude of his mind was at that time receptive, not constructive. It was gathering material, but it had not begun to build. It was watching, arranging, and classifying facts. But it was not selecting from among them such as would fit a plan. Still less was it setting aside any that did not appear to suit. He might have said with truth that which was said by a greater man before him, "*Hypotheses non fingo.*" This is one of the many great charms of the book.

And yet there was one remarkable exception. Like every other voyager who has traversed the vast Southern Ocean, he was struck, impressed, and puzzled by its wonderful coral reefs, its thousands of coral islands, and its still more curious coral "atolls." Why is it that so many of the continents and of the great continental islands whose coasts front or are surrounded by the waters of the Pacific, are fringed and protected by barrier-reefs of coral? The curious question that arises is not why the coral should grow at all, or how it grows. All this, no doubt, is full of wonder—wonder all the greater the more we know of its structure and of the nature of its builder. But let the growth of corals in seas of a certain depth and temperature be assumed and passed over, as we do assume and pass over a thousand other things with which we are familiar. The puzzle here is, why it should grow in the form of a linear barrier along a coast, and yet not touching it, but at a distance more or less great—sometimes very great—and always leaving between it and the land an inclosed and protected space of water which, once they have found an entrance through the reef, ships can navigate for hundreds of miles. Why should this same curious phenomenon be repeated on a smaller scale throughout the thousands of islands and islets which dot the immense surfaces of the Pacific? Why should these islands so often be the center of a double ring—first a ring of calm and as it were inland water, then a ring of coral reef fronting the outer sea, and lastly the ocean-depths out of which the coral reef rises like a wall? Why should this curious arrangement repeat itself in every variety of form over thousands of miles until we come to that extreme case when there is no island at all except the outer ring of the coral reef and an inner pool or lake of shallower water which is thus secluded from the ocean, with nothing to break its surface—shining with a calm, splendid, and luminous green, set off against the deep purple blues of the surrounding sea? For effects so uniform or so analogous, repeated and multiplied over an area so immense, there must be some physical

cause as peculiar as its effects. Moreover, this cause must be one affecting not merely or only the peculiarities of the animal which builds up the coral, but some cause affecting also the solid rocks and crust of the earth. The coral animals must build on some foundation. They must begin by attaching themselves to something solid. Every coral reef, therefore, whatever be its form—every line of barrier-reef however long—every ring however small or however wide, must indicate some corresponding arrangement of subjacent rock. What cause can have arranged the rocky foundations of the coral in such curious shapes? Extreme cases of any peculiar phenomenon are always those which most attract attention, and sometimes they are the cases which most readily suggest an explanation. Ring-shaped islands of such moderate dimensions that the whole of them can be taken in by the eye, supply such cases. There are atoll-islands where ships can enter, through some break in the ring, into the inner circle. They find themselves in a perfect harbor, in a sheltered lake which no wave can ever enter, yet deep enough and wide enough to hold all the navies of the world. Round about on every side there are the dazzling beaches which are composed of coral sand, and crowning these there is the peaceful cocoanut-palm, and a lower jungle of dense tropical vegetation. On landing and exploring the woods and shores, nothing can be seen but coral. The whole island is a ring of this purely marine product; with the exception of an occasional fragment of pumice-stone, which having been floated over the sea from some distant volcanic eruption, like that of Krakatoa, here disintegrates and furnishes clay, the most essential element of a soil. But reason tells us that there must be something else underground, however deeply buried. When the corals first began to grow, they must have found some rock to build upon, and the shape of these walls must be the shape which was thus determined. One suggestion is obvious. Elsewhere all over the globe there is only one physical cause which determines rocky matter into such ring-like forms as these, and which determines also an included space of depth more or less profound. This physical cause is the eruptive action of volcanic force. When anchored in the central lagoon of a coral atoll, are we not simply anchored in the crater of an extinct volcano—its walls represented by the corals which have grown upon it, its crater represented by the harbor in which our ship is lying? The vegetation is not difficult to account for. The coral grows until it reaches the surface. It is known to flourish best in the foaming breakers. These, although confronted and in the main resisted by the wondrous tubes and cells, are able here and there in violent storms to break off the weaker or overhanging portions of the coral and dash them in fragments upon the top of the reef. Often the waves are loaded with battering-rams in the shape of immense quantities of drift-timber. These bring with them innumerable seeds and hard nuts able to retain their vitality while traversing leagues of

ocean. Such seeds again find lodgment among the broken corals, and among the decaying pumice. Under tropical heat and moisture, they soon spring to life. The moment a palm-tree rears its fronds, it is visited by birds—especially by fruit-eating pigeons—bringing with them other seeds, which are deposited with convenient guano. These in turn take root and live. Each new accession to the incipient forest attracts more and more numerous winged messengers from interminable archipelagoes, until the result is attained which so excites our admiration and our wonder, in the atoll-islands of the Pacific. All this is simple. But here as elsewhere it is the first step that costs. Are all atolls nothing more than the cup-like rings of volcanic vents? And if they are, can a like explanation be given for the barrier-reefs which lie off continental coasts, and where the crater-like lagoon of an atoll is represented only by a vast linear expanse of included and protected sea?

Here were problems eminently attractive to such a mind as that of Darwin. Vast in the regions they affect, complicated in the results which are presented, most beautiful and most valuable to man in the products which are concerned, the facts do nevertheless suggest some physical cause which would be simple if only it could be discovered. All his faculties were set to work. Analysis must begin every work of reason. Its function is to destroy—to pull to pieces. Darwin had to deal with some theories already formed. With some of these he had no difficulty. "The earlier voyagers fancied that the coral-building animals instinctively built up these great circles to afford themselves protection in the inner parts." To this Darwin's answer was complete. So far is this explanation from being true, that it is founded on an assumption which is the reverse of the truth. These massive kinds of coral which build up reefs, so far from wanting the shelter of a lagoon, are unable to live within it. They can only live and thrive fronting the open ocean, and in the highly aërated foam of its resisted billows. Moreover, on this view, many species of distinct genera and families are supposed instinctively to combine for one end; and of such a combination Darwin declares "not a single instance can be found in the whole of Nature." This is rather a sweeping assertion. In the sense in which Darwin meant it, and in the case to which he applied it, the assertion is probably, if not certainly, true. The weapon of analysis, however, if employed upon it, would limit and curtail it much. We can not, indeed, suppose that any of the lower animals, even those much higher than the coral-builders, have any consciousness of the ends or purposes which they or their work subserve in the great plan of Nature. But Darwin has himself shown us, in later years, how all their toil is co-operant to ends, and how not only different species and families, but creatures belonging to different kingdoms, work together most directly, however unconsciously, to results on which their common life and propagation abso-

lutely depend. In the case before us, however, this second objection of Darwin is superfluous. The first was in itself conclusive. If the reef-building corals can not live in a lagoon, or in a protected sea, it is needless to argue further against a theory which credits them with working on a plan to insure not their own life and well-being, but their own destruction.

But next, Darwin had to encounter the theory that atoll-islands were built upon extinct volcanoes, and represented nothing but the walls and craters of these well-known structures. This he encountered not with a sweeping assertion, but with a sweeping survey of the vast Pacific. Had those who believed in this theory ever considered how vast that island-bearing ocean was, and how enormous its supposed craters must have been? It was all very well to apply some known cause to effects comparable in magnitude to its effects elsewhere. The smaller atolls might possibly represent volcanic craters. But what of the larger? And what of the grouping? Could any volcanic region of the terrestrial globe show such and so many craters as could correspond at all to the coral islands? One group of them occupies an irregular square five hundred miles long by two hundred and forty broad. Another group is eight hundred and forty miles in one direction, and four hundred and twenty miles in another. Between these two groups there are other smaller groups, making a linear space of more than four thousand miles of ocean in which not a single island rises above the level of true atolls—that is to say, the level up to which the surf can break and heap up the coral masses, and to which the winds can drift the resulting sands. Some atolls seem to have been again partially submerged—"half-drowned atolls," as they were called by Captain Moresby. One of these is of enormous size—ninety nautical miles along one axis, and seventy miles along another. No such volcanic craters or mountains exist anywhere else in our world. We should have to go to the airless and waterless moon, with its vast vents and cinder-heaps, to meet with anything to be compared either in size or in distribution. And then, the linear barrier-reefs lying off continental coasts and the coasts of the great islands are essentially the same in character as the encircling reefs round the smaller islands. They can not possibly represent the walls of craters, nor can the long and broad sheltered seas inside them represent by any possibility the cup-like hollows of volcanic vents.

These theories being disposed of, the work of synthesis began in Darwin's mind. He sorted and arranged all the facts, such as he knew them to be in some cases, such as he assumed them to be in other cases. Above all, like "stout Cortes and his men," from their peak in Darien, "he stared at the Pacific." The actual seeing of any great natural phenomenon is often fruitful. It may not be true in a literal sense that, as Wordsworth tells us, "Nature never did betray the heart that loved her." But it is true that sometimes she discloses

her secrets to an earnest and inquiring gaze. Sometimes things actually are what they look to be. Outwardly they are what their image on the retina directly paints them; and in their history and causes they may be what that image suggests not less directly to the intellect and the imagination. So Darwin, one day, standing on a mountain from which he commanded a wide space of sea, looked down upon an atoll with its curious ring of walled-in water, calm, green, and gleaming in the middle of the oceanic depths of blue. Did it not look as if there had once been an island in the middle? Did it not look as if the coral ring had been built up upon the rocky foundation of its former shores? Did it not look as if, somehow, this island had been removed, and the encircling reef had been left alone? Somehow! This could not satisfy Darwin. How could such an island be removed? Its once fringing and encircling reef would have protected it from the devouring sea. Did it not look as if it had simply sunk? Subsidence! Was not this the whole secret? The idea took firm hold upon his mind. The more he thought of it, the more closely it seemed to fit into all the facts. The coral-fringing reef of the island would not subside along with its supporting rocks, if that subsidence took place slowly, because the coral animals would build their wall upward as fast as their original foundation was sinking downward. And was there not a perfect series of islands in every stage of the suggested operation? There were islands with coral reefs still attached to their original foundations, islands with fringing reefs adhering to them all round, and leaving no lagoons. There were others where the foundations had sunk a little, but not very much, leaving only shallow and narrow spaces of lagoon-water between the island and the barrier-reef. Others there were again where the same process had gone further, and wide and deep lagoons had been established between the reef and the subsiding island. Then there were every variety and degree of the results which must follow from such a process, until we come to the last stage of all, when the island had wholly sunk, and nothing remained but the surviving reef—a true atoll—with its simple ring of coral and its central pool of protected water. Then further it could not but occur to Darwin that the objection which was fatal to the volcano theory was no difficulty in the way of his new conception; on the contrary, it was in strict accordance with that conception. The vast linear reefs lying off straight and continental coasts, which could not possibly represent volcanoes, were completely explained by a vast area of subsiding lands. The reefs were linear because the shores on which they had begun to grow had been linear also. The immense areas of sheltered sea, from twenty to seventy miles in breadth, which often lie between the barrier-reefs and the existing shores, for example, of Australia and New Guinea, were explained by the comparatively shallow contours of land which had gradually subsided and had left these great spaces

between the original fringing reef and the existing shores. The more Darwin pondered, the more satisfied he became that he had found the clew. The cardinal facts were carefully collated and compared. First, there was the fact that the reef-building corals could not live at any greater depth than from twenty to thirty fathoms. Secondly, there was the fact that they can not live in water charged with sediment, or in any water protected from the free currents, the free winds, and the dashing waves of the open and uncontaminated sea—that vast covering of water which in the southern hemisphere is world-wide and world-embracing. Thirdly, there was the fact that the coral reefs rise suddenly like a wall out of oceanic depths, soundings of a thousand fathoms and more being constantly found close up to the barrier-reefs. Fourthly, there is the fact that on the inner side, next the island or the continent which they inclose or protect, the lagoon or the sheltered area is often very deep close to the reef, not indeed affording oceanic soundings, but nevertheless soundings of twenty to thirty fathoms. All these facts are indisputably true. Taking them together, the conclusions or inferences to which they point may well seem inevitable. Let us hear how Darwin himself puts them in the short summary of his theory which is given in the latest edition of his "Journal":

From the fact of the reef-building corals not living at great depths, it is absolutely certain that throughout these vast areas, wherever there is now an atoll, a foundation must have originally existed within a depth of from twenty to thirty fathoms from the surface. It is improbable in the highest degree that broad, lofty, isolated, steep-sided banks of sediment arranged in groups and lines hundreds of leagues in length, could have been deposited in the central and profoundest parts of the Pacific and Indian Oceans, at an immense distance from any continent, and where the water is perfectly limpid. It is equally improbable that the elevatory forces should have uplifted throughout the above vast area, innumerable great rocky banks within twenty to thirty fathoms, or one hundred and twenty to one hundred and eighty feet, of the surface of the sea, and not one single point above that level; for where on the face of the whole globe can we find a single chain of mountains, even a few hundred miles in length, with their many summits rising within a few feet of a given level, and not one pinnacle above it? If then the foundations, whence the atoll-building corals sprang, were not formed of sediment, and if they were not lifted up to the required level, they must of necessity have subsided into it; and this at once solves the difficulty. For as mountain after mountain, and island after island, slowly sank beneath the water, fresh bases would be successively afforded for the growth of the corals.

So certain was Darwin of these conclusions that he adds, in a most unwonted tone of confidence:

I venture to defy any one to explain in any other manner how it is possible that numerous islands should be distributed throughout vast areas—all the islands being low, all being built of corals, absolutely requiring a foundation within a limited depth from the surface.*

* "Journal," p. 468.

The voyage of the Beagle ended in the autumn of 1836, and Darwin landed in England on the 2d of October. He proceeded to put into shape his views on the coral islands of the Pacific, and in May, 1837, they were communicated to the public in a paper read before the Geological Society of London. His theory took the scientific world by storm. It was well calculated so to do. There was an attractive grandeur in the conception of some great continent sinking slowly, slowly, into the vast bed of the Southern Ocean, having all its hills and pinnacles gradually covered by coral reefs as in succession they sank down to the proper depth, until at last only its pinnacles remained as the basis of atolls, and these remained, like buoys upon a wreck, only to mark where some mountain-peak had been finally submerged. Besides the grandeur and simplicity of this conception, it fitted well into the Lyellian doctrine of the "bit-by-bit" operation of all geological causes—a doctrine which had then already begun to establish its later wide popularity. Lyell had published the first edition of his famous "Principles" in January, 1830—that is to say, almost two years before the Beagle sailed. He had adopted the volcanic theory of the origin of the coral islands; and it is remarkable that he had nevertheless suggested the idea, although in a wholly different connection, that the Pacific presented in all probability an area of subsidence. Darwin most probably had this suggestion in his mind when he used it and adopted it for an argument which its author had never entertained.* However this may be, it must have prepared the greatest living teacher of geology to adopt the new explanation which turned his own hint to such wonderful account. And adopt it he did, accordingly. The theory of the young naturalist was hailed with acclamation. It was a magnificent generalization. It was soon almost universally accepted with admiration and delight. It passed into all popular treatises, and ever since for the space of nearly half a century it has maintained its unquestioned place as one of the great triumphs of reasoning and research. Although its illustrious author has since eclipsed this earliest performance by theories and generalizations still more attractive and much further reaching, I have heard eminent men declare that, if he had done nothing else, his solution of the great problem of the coral islands of the Pacific would have sufficed to place him on the unsubmergeable peaks of science, crowned with an immortal name.

And now comes the great lesson. After an interval of more than five-and-thirty years the voyage of the Beagle has been followed by the voyage of the Challenger, furnished with all the newest appliances of science, and manned by a scientific staff more than competent to turn them to the best account. And what is one of the many results that have been added to our knowledge of Nature—to our estimate of the true character and history of the globe we live

* Lyell's "Principles," eleventh edition, p. 595.

on? It is that Darwin's theory is a dream. It is not only unsound, but it is in many respects directly the reverse of truth. With all his conscientiousness, with all his caution, with all his powers of observations, Darwin in this matter fell into errors as profound as the abysses of the Pacific. All the acclamations with which it was received were as the shouts of an ignorant mob. It is well to know that the *plébiscites* of science may be as dangerous and as hollow as those of politics. The overthrow of Darwin's speculation is only beginning to be known. It has been whispered for some time. The cherished dogma has been dropping very slowly out of sight. Can it be possible that Darwin was wrong? Must we indeed give up all that we have been accepting and teaching for more than a generation? Reluctantly, almost sulkily, and with a grudging silence as far as public discussion is concerned, the ugly possibility has been contemplated as too disagreeable to be much talked about. The evidence, old and new, has been weighed and weighed again, and the obviously inclining balance has been looked at askance many times. But, despite all averted looks, I apprehend that it has settled to its place forever, and Darwin's theory of the coral islands must be relegated to the category of those many hypotheses which have indeed helped science for a time by promoting and provoking further investigation, but which in themselves have now finally "kicked the beam."

But this great lesson will be poorly learned unless we read and study it in detail. What was the flaw in Darwin's reasoning, apparently so close and cogent? Was it in the facts, or was it in the inferences? His facts in the main were right; only it has been found that they fitted into another explanation better than into his. It was true that the corals could only grow in a shallow sea, not deeper than from twenty to thirty fathoms. It was true that they needed some foundation provided for them at the required depth. It was true that this foundation must be in the pure and open sea, with its limpid water, its free currents, and its dashing waves. It was true that they could not flourish or live in lagoons or in channels, however wide, if they were secluded and protected from oceanic waves. One error, apparently a small one, crept into Darwin's array of facts. The basis or foundation on which corals can grow, if it satisfied other conditions, need not be solid rock. It might be deep-sea deposits if these were raised or elevated near enough the surface. Darwin did not know this, for it is one of his assumptions that coral "can not adhere to a loose bottom."* The Challenger observations show that thousands of deep-sea corals and of other lime-secreting animals flourish on deep-sea deposits at depths much greater than those at which true reef-building species are found. The dead remains of these deeper-living animals, as well as the dead shells of pelagic species that fall from the surface waters, build up submarine

* "Journal," edition 1852, p. 477.

elevations toward the sea-level. Again, the reef-building coral will grow upon its own *dēbris*—rising, as men, morally and spiritually, are said by the poet to do, "on stepping-stones of their dead selves to higher things." This small error told for much; for if coral could grow on deep-sea deposits when lifted up, and if it could also grow seaward, when once established, upon its own dead and sunken masses, then submarine elevations and not submarine subsidences might be the true explanation of all the facts. But what of the lagoons and the immense areas of sea behind the fringing reefs? How could these be accounted for? It was these which first impressed Darwin with the idea of subsidence. They looked as if the land had sunk behind the reef, leaving a space into which the sea had entered, but in which no fresh reefs could grow. And here we learn the important lesson that an hypothesis may adequately account for actual facts, and yet nevertheless may not be true. A given agency may be competent to produce some given effect, and yet that effect may not be due to it, but to some other. Subsidence would or might account for the lagoons and for the protected seas, and yet it may not be subsidence which has actually produced them.

Darwin's theory took into full account two of the great forces which prevail in Nature, but it took no account of another, which is comparatively inconspicuous in its operations, and yet is not less powerful than the vital energies, and the mechanical energies, which move and build up material. Darwin had thought much and deeply on both of these. He called on both to solve his problem. To the vital energy of the coral animals he rightly ascribed the power of separating the lime from sea-water, and of laying it down again in the marvelous structures of their calcareous homes. In an eloquent and powerful passage he describes the wonderful results which this energy achieves in constructing breakwaters which repel and resist the ocean along thousands of miles of coast. On the subterranean forces which raise and depress the earth's crust he dwelt—at least enough. But he did not know, because the science of his day had not then fully grasped, the great work performed by the mysterious power of chemical affinity, acting through the cognate conditions of aqueous solution. Just as it did not occur to him that a coral reef might advance steadily seaward by building ever-fresh foundations on its own fragments when broken and submerged, or that the vigorous growth of the reefs to windward was due to the more abundant supply of food brought to the reef-building animals from that direction by oceanic currents, so did it never occur to him that it might melt away to the rear like salt or sugar, as the vital energy of the coral animals failed in the sheltered and comparatively stagnant water. It was that vital energy alone which not only built up the living tubes and cells, but which filled them with the living organic matter capable of resisting the chemical affinities of the inorganic world.

But when that energy became feeble, and when at last it ceased, the once powerful structure descended again to that lower level of the inorganic, and subject to all its laws. Then, what the ocean could not do by the violence of its waves, it was all-potent to do by the corroding and dissolving power of its calmer lagoons. Ever eating, corroding, and dissolving, the back waters of the original fringing reef—the mere pools and channels left by the outrageous sea as it dashed upon the shore—were ceaselessly at work, aided by the high temperature of exposure to blazing suns, and by the gases evolved from decaying organisms. Thus the enlarging area of these pools and channels spread out into wide lagoons, and into still wider protected seas. They needed no theory of subsidence to account for their origin or for their growth. They would present the same appearance in a slowly-rising, a stationary, or a slowly-sinking area. Their outside boundary was ever marching farther outward on submarine shoals and banks, and ever as it advanced in that direction its rear ranks were melted and dissolved away. Their inner boundary —the shores of some island or of some continent—might be steady and unmoved, or it might be even rather rising instead of sinking. Still, unless this rising were such as to overtake the advancing reef, the lagoon would grow, and, if the shores were steady, it would widen as fast as the face of the coral barrier could advance. Perhaps, even if such a wonderful process had ever occurred to Darwin—even if he had grasped this extraordinary example of the "give and take" of Nature—of the balance of opposing forces and agencies which is of the very essence of its system, he would have been startled by the vast magnitude of the operations which such an explanation demanded. In its incipient stages this process is not only easily conceivable, but it may be seen in a thousand places and in a thousand stages of advancement. There are islands without number in which the fringing reef is still attached to the shore, but in which it is being "pitted," holed, and worn into numberless pools on the inner surfaces where the coral is in large patches dead or dying, and where its less soluble ingredients are being deposited in the form of coral sand. There are thousands of other cases where the lagoon interval between the front of the reef and the shores has been so far widened that it is taking the form of a barrier, as distinguished from a fringing reef, and where the lagoon can be navigated by small boats. But when we come to the larger atolls, and the great seas included between a barrier-reef and its related shores, the mind may well be staggered by the enormous quantity of matter which it is suggested has been dissolved, removed, and washed away. The breadth of the sheltered seas between barrier-reefs and the shore is measured in some cases not by yards or hundreds of yards, not by miles, but by tens of miles, and this breadth is carried on in linear directions, not for hundreds of miles, but for thousands. And yet there is one familiar idea in geol-

ogy which might have helped Darwin, as it is much needed to help us even now, to conceive it. It is the old doctrine of the science long ago formulated by Hutton, that the work of erosion and of denudation must be equal to the work of deposition. Rocks have been formed out of the ruins of older rocks, and those older rocks must have been worn down and carried off to an equivalent amount. So it is here, with another kind of erosion and another kind of deposition. The coral-building animals can only get their materials from the sea, and the sea can only get its materials by dissolving it from calcareous rocks of some kind. The dead corals are among its greatest quarries. The inconceivable and immeasurable quantities which have been dissolved out of the lagoons and sheltered seas of the Pacific and of the Indian Ocean are not greater than the immeasurable quantities which are again used up in the vast new reefs of growing coral, and in the calcareous covering of an inconceivable number of other marine animals.

Here, then, was a generalization as magnificent as that of Darwin's theory. It might not present a conception so imposing as that of a whole continent gradually subsiding, of its long coasts marked by barrier-reefs, of its various hills and irregularities of surface, marked by islands of corresponding size, and finally of the atolls which are the buoys, indicating where its highest peaks finally disappeared beneath the sea. But, on the other hand, the new explanation was more like the analogies of Nature—more closely correlated with the wealth of her resources, with those curious reciprocities of service, which all her agencies render to each other, and which indicate so strongly the ultimate unity of her designs. This grand explanation we owe to Mr. John Murray, one of the naturalists of the Challenger expedition, a man whose enthusiasm for science, whose sagacity and candor of mind, are not inferior to those of Darwin, and whose literary ability is testified by the splendid volumes of "Reports" now in course of publication under his editorial care. Mr. Murray's new explanation of the structure and origin of coral reefs and islands was communicated to the Royal Society of Edinburgh in 1880,* and supported with such a weight of facts, and such a close texture of reasoning, that no serious reply has ever been attempted. At the same time, the reluctance to admit such an error in the great Idol of the scientific world, the necessity of suddenly disbelieving all that had been believed and repeated in every form, for upward of forty years—of canceling what had been taught to the young of more than a whole generation —has led to a slow and sulky acquiescence, rather than to that joy which every true votary of science ought to feel in the discovery of a new truth and—not less—in the exposure of a long-accepted error. Darwin himself had lived to hear of the new solution, and with that splendid candor which was eminent in him, his mind, though now

* "Proceedings of the Royal Society of Edinburgh," vol. x, pp. 505–518.

grown old in his own early convictions, was at least ready to entertain it, and to confess that serious doubts had been awakened as to the truth of his famous theory.

If, however, Mr. John Murray has not been cheered by the acclamations which greeted his illustrious predecessor, if the weight of a great accepted authority and of preconceived impressions has kept down the admiration which ought ever to reward the happy suggestions of laborious research, he has had at least the great satisfaction of observing the silence of any effective criticism. But more than this—he is now having the still greater satisfaction of receiving corroborative support from the observations of others. His own series of facts as ascertained during the voyage of the Challenger constituted an array of evidence tolerably conclusive. But since he read his paper in Edinburgh, an island has been discovered in the Solomon group by another naturalist, Dr. Guppy,* which lifts into the light and air a complete record of the series of operations beneath the waters of the Pacific to which Mr. Murray ascribes the origin of countless other islands, islets, and atolls. Here the barrier-reef and the atoll have been elevated from their bed, and all their foundations have been shown. Those foundations are not solid rock, but are just what Darwin assumed they could never be—deep-sea deposits. These had been originally, of course, laid down in more or less oceanic depths. But elevation, not depression, had begun the work. The deep deposit had ceased to be deep because the crust of the earth, on which it lay, had been bulged upward by subterranean force. The deep bottom had become a shoal, rising to the required distance from the surface-level of the sea. The moment it reached the thirty or the twenty fathom depth, the reef-building corals seized upon it as their resting-place, and began to grow. Possibly some process of induration may have affected the deposit before it reached this point. Probably it was consolidated or indurated by the luxuriant growth of myriads of deep-sea creatures at depths greater than thirty fathoms.

It has recently been discovered, by another naturalist of the Challenger school,† that there may be a special explanation of this part of the operation. It is found that shoals have the immediate effect of converting the tidal wave of deeper water into a current. This current sweeps off the looser deposits covering the shoal. Deep-sea corals then settle upon it. These may, and often do, build up their walls to a great height, and if this height reaches the zone of the true reef-building species, a firm basis is at once provided for their operations. Shoals have lately been discovered off the African coasts of the Atlantic, which in tropical seas would probably have become coral

* Surgeon of H. M. S. Lark. "Transactions of the Royal Society of Edinburgh," June, 1885.

† "On Oceanic Shoals discovered by the steamship Dacia," by J. Y. Buchanan, F. R. S. E., "Proceedings of the Royal Society of Edinburgh," October, 1883.

islands. This may or may not have been often the case in the Pacific. But it does not affect the question, except in so far as it may justify Darwin's conception that reef corals can not grow on "loose deposits." They may have ceased to be so soft and loose as they are when resting in the quiet depths of the thousand-fathoms sea. This induration may be part or an accompaniment of the process of elevation, but whether it be so or not the process is equally one of elevation and not of subsidence. In the island described by Dr. Guppy, the foundations of the reef-building corals are seen resting directly on the remains of the pelagic fauna, and both theories equally assume and assert the uncontested fact that these foundations when the coral wall began to grow must have been previously elevated to the requisite level, that, namely, of from one hundred and eighty to one hundred and twenty feet below the surface of the ocean. Mr. John Murray's explanation is fully confirmed that the coral reefs often begin on shoals; that these shoals are due to elevations of the sea-bottom; that the reef when once established can and does grow seaward upon its own fragments broken and submerged; that these form a "talus" capable of indefinite advance until the farthest limit of the shoal is reached; that the rearward ranks of the coral animals die as they are left behind in the hot and shallow waters of the lagoon; that their calcareous skeletons are then attacked by the solvent action of the water, are eaten away and carried off to form the materials of new reefs and the shells of countless other creatures. These have likewise been confirmed by the investigations of Mr. Alexander Agassiz in the West Indies. Often in the Pacific, as in all other regions of the earth, the elevating forces rest for ages, having done all the work which on some particular area they have got to do. The shoals remain shoals, only covered with the walls and battlements of coral. This is the case which accounts for countless islands never exceeding a certain height. On the other hand, and "otherwhere," the elevating forces, after a rest, resume their operation, lift up these coral walls and battlements wholly out of the sea, and make other islands by the thousand which become the delight of man; while in yet another class of cases the elevations open out into volcanoes, and constitute great areas of land which are among the most fertile regions of the habitable globe. But everywhere and always the ubiquitous coral animals fix on every shoal and on every shore whether old or new, and resume the wonderful cycle of operations in which they are a subordinate but a powerful agent.

In a recent article in this Review I had occasion to refer to the curious power which is sometimes exercised on behalf of certain accepted opinions, or of some reputed prophet, in establishing a sort of Reign of Terror in their own behalf, sometimes in philosophy, sometimes in politics, sometimes in science. This observation was received as I expected it to be—by those who, being themselves sub-

ject to this kind of terror, are wholly unconscious of the subjection. It is a remarkable illustration of this phenomenon that Mr. John Murray was strongly advised against the publication of his views in derogation of Darwin's long-accepted theory of the coral islands, and was actually induced to delay it for two years. Yet the late Sir Wyville Thomson, who was at the head of the naturalists of the Challenger expedition, was himself convinced by Mr. Murray's reasoning, and the short but clear abstract of it in the second volume of the narrative of the voyage has since had the assent of all his colleagues.*

Nor is this the only case, though it is the most important, in which Mr. Murray has had strength to be a great iconoclast. Along with the earlier specimens of deep-sea deposits sent home by naturalists during the first soundings in connection with the Atlantic telegraph cable, there was very often a sort of enveloping slimy mucus in the containing bottles which arrested the attention and excited the curiosity of the specialists to whom they were consigned. It was structureless to all microscopic examination. But so is all the protoplasmic matter of which the lowest animals are formed. Could it be a widely-diffused medium of this protoplasmic material, not yet specialized or individualized into organic forms, nor itself yet in a condition to build up inorganic skeletons for a habitation? Here was a grand idea. It would be well to find missing links; but it would be better to find the primordial pabulum out of which all living things had come. The ultra-Darwinian enthusiasts were enchanted. Haeckel clapped his hands and shouted out Eureka loudly. Even the cautious and discriminating mind of Professor Huxley was caught by this new and grand generalization of the "physical basis of life." It was announced by him to the British Association in 1868. Dr. William Carpenter took up the chorus. He spoke of "a living expanse of protoplasmic substance," penetrating with its living substance the "whole mass" of the oceanic mud.† A fine new Greek name was devised for this mother slime, and it was christened "Bathybius," from the consecrated deeps in which it lay. The conception ran like wildfire through the popular literature of science, and here again there was something like a coming *plébiscite*, in its favor. Expected imagination soon played its part. Wonderful movements were seen in this mysterious slime. It became an "irregular network," and it could be seen gradually "altering its form," so that "entangled granules gradually changed their relative positions."‡ The naturalists of the Challenger began their voyage in the full Bathybian faith. But the sturdy mind of Mr. John Murray kept its balance—all the more easily since he never could himself find or see any trace of this pelagic protoplasm when the dredges of the Chal-

* "Narrative of the Challenger Expedition," vol. i, p. 781.

† "Proceedings of the Royal Society," No. 107, 1868, pp. 190, 191.

‡ "The Depths of the Sea," second edition, London, 1874, pp. 410–415.

lenger came fresh from bathysmal bottoms. Again and again he looked for it, but never could he discover it. It always hailed from home. The bottles sent there were reported to yield it in abundance, but somehow it seemed to be hatched in them. The laboratory in Jermyn Street was its unfailing source, and the great observer there was its only sponsor. The ocean never yielded it until it had been bottled. At last, one day on board the Challenger an accident revealed the mystery. One of Mr. Murray's assistants poured a large quantity of spirits of wine into a bottle containing some pure sea-water, when lo! the wonderful protoplasm Bathybius appeared. It was the chemical precipitate of sulphate of lime produced by the mixture of alcohol and sea-water. This was bathos indeed! On this announcement "Bathybius" disappeared from science, reading us, in more senses than one, a great lesson on "precipitation."*

This is a case in which a ridiculous error and a ridiculous credulity were the direct results of theoretical preconceptions. Bathybius was accepted because of its supposed harmony with Darwin's speculations. It is needless to say that Darwin's own theory of the coral islands has no special connection with his later hypotheses of evolution. Both his theory and the theory of Mr. Murray equally involve the development of changes through the action and interaction of the old agencies of vital, chemical, and mechanical change. Nevertheless, the disproof of a theory which was so imposing, and had been so long accepted, does read to us the most important lessons. It teaches us that neither the beauty—nor the imposing character—nor the apparent sufficiency of an explanation may be any proof whatever of its truth. And if this be taught us even of explanations which concern results purely physical, comparatively simple, and comparatively definite, how much more is this lesson impressed upon us when, concerning far deeper and more complicated things, explanations are offered which are in themselves obscure, full of metaphor, full of the pitfalls and traps due to the ambiguities of language—explanations which are incapable of being reduced to proof, and concern both agencies and results of which we are profoundly ignorant!—*Nineteenth Century.*

* "Narrative of the Challenger Expedition," vol. i, p. 939.

PRESIDENT WOODWARD, of Washington College, St. Louis, gave to the American Association an excellent account of the results of the manual training course at that institution. After three years of it, the boys could go out and succeed in any trade they entered; and their capacity and excellence were acknowledged by master-workmen. Professor E. J. James regarded the introduction of this branch as the next great step in the development of our educational system. It would give symmetry to our now one-sided and defective system of public instruction; would induce a better attendance at the schools; would remove all traces of stigma from labor, and gradually elevate the social tone of our workmen; and would aid in developing intellectual and industrial ability now lying dormant in thousands of our children.

THE COLOR OF WORDS.

By N. E. NEWELL.

THERE are some curious things in regard to the way in which the human mind is affected by colors as well as the human sight. We are all familiar with what is termed color-blindness, and the unexpected results that sometimes attend it; but color-sound is something which has received much less investigation.

How much, or in what way, animals are affected by colors, is not very well understood; but the subject has been investigated enough to know that they are influenced by them, and the future will probably bring out some surprising results to the one who shall thoroughly cultivate this comparatively unexplored field of research.

Some people can select and appreciate the colors of sounds; and to them the speaking of a name presents, mentally, a well-defined color, or combination of colors, different names having different shades or combinations.

The same name should, of course, always present the same color, or combination, when spoken, although, to different people, possessing the faculty, a given name or sound does not present the same characteristics. To prove the first of these two facts, a list of names was prepared, and the shade or color given by a lady who has this power, marked against each one of the list. After several weeks the names were again read to her, and the colors designated by her marked. This course was pursued several times during a year or more, the lady not being allowed to see the results in that time. During these several experiments the only variations in the answers given were such as would be natural where there was some uncertainty in regard to terms: for example, the answer to a given name at one time might be, "bluish," and at another, "lead-color"; so, what was called "straw-color" might be afterward called "buff." The approach to similarity in the shades shows that the same mental picture was present, and only language was at fault.

With one or two exceptions these were the only changes noted in the several trials; and the extent to which the experiments were carried warrants the belief that there was a well-defined idea of the color of words.

A few years ago a New York physician had two patients that probably had this faculty of the mind abnormally developed: one had a horror of all words in which the letters *ch* were placed; and the other was taken with hysterics at a certain shade of blue. Whether or not the latter case has any bearing on the subject, may be questioned; but it seems as though a perception so acute in regard to certain colors would involve the power of word-coloring.

Following are the words and the colors assigned to them in the experiments noted above, including a few double numbers: 1, black; 2, light-cream; 3, dark-cream; 4, brownish-red; 5, black; 6, tan-color or cream; 7, greenish-black; 8, dark-straw; 9, mud-color; 10, black; 21, black and straw; 22, light-cream; 23, dark straw-color; 24, light and brown.

Some three years ago Professor E. S. Holden contributed a paper to "Science" on "Visualized Numbers," in which examples were given that differ in some points from the results obtained by the writer. For the purpose of comparing, I quote from Professor Holden's article: "1, black; 2, cream; 3, blue; 4, brown; 5, white; 6, crimson-pink; 8, white; 9, greenish; 10, brown."

It will be seen that where there is a variation it is a radical one. I do not attempt to explain the reason, but state it as a curious example of mental idiosyncrasy.

Following some familiar names are given, and the color of each, and also the letters of the alphabet: Mary, dark-red; Abbie, tan; Lucy, dark-blue; Richard, light-gray; Atalanta, steel-gray; Charlotte, light-red; Claire, light-blue; Newcomb, dark-red; Lincoln, black; Morse, brown; Newhall, gray-black; Frank, dark-green; A, light-straw; B, gray; C, tan; D, blue; E, black; F, black; G, light-straw; H, red; I and J, black; K, blue; L, black; M, brown; N, dark-blue; O, light-red; P, light-green; Q, blue; R and S, light-straw; T, green; U, gray; V, yellow; W, blue; X, gray; Y and Z, dark-brown.

"Color-hearing" has been considered in "The Popular Science Monthly" [August, 1883]. I quote from the article: "There are, in fact, persons who are endowed with such sensibility that they could not hear a sound without at the same time perceiving colors." These are the colors of sounds, and the sound of colors is what can be regarded as another branch of the same scientific mystery. Dr. Sophus Trombolt has investigated in this direction and according to the testimony of one hundred and forty-four persons in Norway in relation to the emission of sound by the northern lights, ninety-two were found who believed in such sounds, and fifty-three asserted that they had heard them. The sound was described as sizzling, hissing, whizzing, crackling, rushing, rippling, rolling, flapping, creaking, and roaring.

[NOTE BY THE EDITOR.—Connected with this subject it may be well to recall an interesting relation of experiences which was started several years ago by Mr. Francis Galton, respecting what he designated "visualized numerals," and the association of colors with various numbers. The term "visualized numerals" in its simplest sense means the conception, or mental vision, when any number is spoken or thought of, of that number as it is written, the power to form which may extend in some cases to lines of considerable length. In a fuller sense the term means more, and may be associated with very curious

shapes and orders in which the digits or numbers arrange themselves, of which a considerable variety have been described by Mr. Galton and his correspondents, and by M. Jaques Bertillon. One correspondent reported to Mr. Galton that when a child he counted by imaginary cards from one to ten, and his little boy in the same way used an imaginary domino; another pictured numbers in groups of so many dots; to the same person, the numbers, from the part they played in the multiplication-table, had been personified. Thus, 9 was a wonderful being of whom he felt almost afraid; 8 was his wife; "and there used always to seem a fitness in 9×9 being so much more than 8×8"; 7 was masculine; 6, of no particular sex, but gentle and straightforward; 3, a feeble edition of 9, and generally mean; 2, young and sprightly; 1, a commonplace drudge. "In this style the whole multiplication-table consisted of the actions of living persons, whom I liked and disliked, and who had, though only vaguely, human forms." Mr. George Bidder, who was known in early life as "the calculating-boy," saw the numbers arranged in their order along a concavely-scalloped curve, the first part of which, comprising the first ten numbers, followed the arrangement of figures on a clock-face.

Another person's experience was to see the numbers arranged in association with certain colors up to 108. After 108 the notion of place became hazy and indistinct, though visualization was still possible, with effort. This writer as a child had a great liking for 6, arising, possibly, from his desire to be six years old. He was also very fond of blue, the color which he associated with 6. One of this writer's sisters saw numerals in a differently arranged diagram, and the figures themselves colored, each its own color. Another sister and a brother saw the figures in diagrams, but less clearly. The effects of heredity were strongly marked in two families of cousins. A sister in the first family saw the figures up to 200 in a rather complicated arrangement in a kind of cloud-land of different degrees of shading; another sister saw them ascending in a directly perpendicular line in front of the eye up to 1,000, when they became vague and seemed to turn to the left. A brother saw them in a straight line from left to right, black, on a ground varying in illumination—the millions in a vague, bright distance to the right. Other members of these families associated them with figures or with linear arrangements peculiar to themselves.

To another writer the figures presented themselves in an intricate curve, in which "the zero-point never moves; it is *in* my mind; it is that point of space known as 'here,' while all other points are outside, or 'there.' When I was a child, the zero-point began the curve; now it is a fixed point in an infinite circle." To another, who saw the numerals arranged for the most part in a regular row, like park palings, they appeared as far as 12 to be concealed in black shadow; from 12 to 20 was illuminated space, in which he could distinguish no divisions.

A person who was described as a mathematical astronomer, of rapidly-rising reputation, saw the numbers in a straight row, while he would be standing a little on one side. They went away in the distance, so that 100 was the farthest number be could see distinctly. The row was dusky-gray, and paler near to the observer. The tens were marked by a kind of fleecy lumps.

M. d'Abbadie made a communication on the peculiarities of numerical vision to the Anthropological Society of Paris, and this led M. Jaques Bertillon to relate his experiences in the matter, beginning with the time when he learned to count. "I connected," he says, "each of the numbers as it was taught me with some object in our garden, so that when I went over the series I would in imagination walk along an alley that led from the house to the end of the garden. Thus, an indestructible association of ideas arose between the figures and the plants in the garden: the figure 1 became attached to a chestnut-tree that marked the beginning of the walk, the figure 5 to a bench near it, the figure 7 to a tub farther on, the number 14 to a little laurel; 30 and the following figures were lost in a dark avenue of trees that terminated the walk; while beyond 40 the numbers ceased to be associated with any object, probably because I had not learned to count further when I made the pleasant associations. If I wished to add 14 and 5, I would in fancy go to the place (the laurel-bush) that 14 occupied in the garden, and go some steps farther to 19. The puerile work was wholly involuntary; and I well recollect when my tendency to proceed thus was almost invincible. I had another process for fractions: the idea of $\frac{1}{4}$, for example, was directly associated with the idea of a quarter of an hour marked on the clock; and if I had to add $\frac{1}{4}$ and $\frac{1}{3}$, I imagined the hand pushed forward twenty minutes, or one third of an hour, and I immediately had the result, $\frac{7}{12}$. I was not able, however, to calculate any fractions in this way the denominators of which were not factors of 60."

A professor of mathematics in Geneva saw the numbers in a zig-zag line which made turns at 10 and at 60, up to 116, and no further, and added to his description that when young he likened some sounds to colors: a grave sound was black, a less grave one, red; an acute sound, yellow; a very acute one, bright yellow.

Another correspondent saw the numbers arranged in their regular orders in a system of lines—the first 10 in a horizontal line, the next 10 in a line perpendicular to it, the third 10 in a line running diagonally from right to left, the numbers from 30 to 90 in a perpendicular line parallel to the line of the second series, and the larger numbers to 1,000 in a line running from right to left parallel with the first one. The vision stopped at 1,000.

To another correspondent of M. Bertillon's the numbers presented themselves—not very clearly distinct from one another—in a descending column, quite narrow down to 10, where it doubled in width;

from 16 to 20 the column swelled out till it formed a rectangle twice as broad as the double column from 10 to 16; passing 20, the column narrowed again, changed direction, and ascended perpendicularly, but in such a way that it was impossible to tell how the new column was connected with the former descending column; but it went up, whatever might be the fate of the other column, presenting its rectangular swelling at every 10. Passing 50, it curved to the right, still retaining its dimensions and its swelling at every 10, then descended in a curve to 100, where the vision stopped.

All of the seers so far quoted had the numbers presented to them in a plane. One other one described his vision as that of an arrangement around the three sides of a triangular prism. On the first face appeared the first 30 numbers, running in a zigzag line, 10 and 30 being seen at apical angles, 20 at a depressed angle; on the second face the numbers from 30 to 100 ran in a straight horizontal line; and on the third face those from 100 to 1,000 in a straight ascending line. The spiral returning to the first face of the prism, the numbers from 1,000 to 30,000 appeared upon it in a zigzag line parallel to the first line of 1 to 30. The second face again contained the numbers from 30,000 to 100,000, and the third face those from 100,000 to 1,000,000 in lines parallel to the other lines on the same faces.]

JOHN JACOB BAEYER.

By J. HOWARD GORE.

WHEN Frederick the Great, June 22, 1740, wrote, "In this country every man must get to heaven his own way," there were many sturdy Germans who were glad to embrace the opportunity to turn aside from the route to which the beliefs of their ancestors restricted them. But they did not wish to be alone upon the unknown sea into which their independence had launched them; every one felt the need of that encouragement which comes from the association of those whose aims and methods are the same. To secure this, the gracious sovereign allowed colonies to be formed of those of like faith and order. One of these colonies was Müggelsheim, about fourteen miles southeast of Berlin. Among the founders of this village there was a "faithful follower" who came from Odernheim seeking that religious sympathy which was here vouchsafed. This pilgrim sat as magistrate in the new settlement, while another coming from Mainz was the school-teacher; these two became connected by the former's son marrying the latter's daughter. On the 5th of November, 1794, this couple rejoiced over the birth of a son—Johan Jacob Baeyer. The first few years of the lad were uneventful; he watched the geese, herded the cattle, and laid, in healthful exercise, the foundation for a

vigorous, active life. He was sent to the village school until he was thirteen years old. Here the pupil's talents were proudly observed and duly fostered by the teacher, his grandfather, who noticed especially the wonderful memory of the youth.

This capability seems to have been the moving cause that prompted the parents to give Baeyer the advantages of a better course of instruction. They sought to find this in the person of Gronau, the pastor in the neighboring town, Köpenick. Here he remained three years, going thence to the gymnasium in Joachimsthal, where he entered the fourth class.

Before completing the course here, the breaking out of the War of 1813 fired him with a thirst for military experience, which he obtained as a volunteer in the Third East Prussian Infantry, serving until the declaration of peace in 1814. He then returned to his gymnasium studies, to be again interrupted by the outbreak in 1815. The repeated inclinations to be a soldier were gratified by again enlisting in the army, this time as an officer in the Fourth Rhine militia. This life had a charm for him; so, at the close of the war, he attended the military school at Coblenz, and in 1821, through the intervention of General von Müffling, who had become acquainted with Baeyer's predilection for geodetic work, he was detailed to the general staff.

It was at this time that Von Müffling was engaged upon the arc of longitude extending from Dunkirk, the extremity of the French arc of latitude, to Seeberg. In this work Baeyer assisted, especially in the computations, receiving in return his chief's ardent thanks in the preliminary report published in the "Astronomische Nachrichten," 1822, No. 27.

The year 1822 was perhaps a pivotal year to Baeyer. Just while comparing the life of a soldier with that of a scientist, at a time when he had obtained a place of honor in the military service, and had also been publicly thanked by a distinguished man for scientific work, he met Alexander von Humboldt and Bessel. The former was planning a second trip around the world for the purpose of collecting items of interest, and thought that he had found in this clever, energetic officer, now in his twenty-seventh year, the person to place in charge. The proposition was formally made, and so seriously considered that by way of preparation Baeyer attended the lectures of Weiss on mineralogy and geognosy during the two following years. For certain reasons the plan fell short of consummation, but Humboldt's friendship and example were always great incentives to his youthful friend. Bessel also followed the career of Baeyer with interest, and saw in later years that his talents and skill were of such character as to bring them together as co-workers, assisting one another. He was promoted to first lieutenant in 1823, and in the following year he was one of a party that made a survey of the Suwarrow route over the Alps, during which he ascertained, by means of a barometer, the alti-

tudes of more than a hundred stations. Poggendorff paid him the compliment of discussing one of these determinations in "Annalen der Physic und Chemie," vol. ii, 1825, pp. 109–112.

In 1825 he was appointed a member of the faculty of the military school at Berlin, at first teaching pure and afterward applied mathematics; and from 1832 to 1857 he had charge of the department of geodesy, lecturing on the theory during the winter and working at it practically during the summer months. It was at the very beginning of his course in geodesy that Bessel secured his assistance in that monumental work, the degree-measurement in East Prussia, the results of which were published in 1838 under their joint authorship. While Bessel is known as the leading spirit in this undertaking, Baeyer's skill in handling instruments, his interest in base-measuring, and his efficiency in recognizance, contributed no little to its success. The accuracy, watchfulness, and painstaking detail of the enthusiastic officer stimulated Bessel to do his best; and this best so impressed itself upon Baeyer that posterity has become his debtor for having handed down and improved the methods of his honored master.

Before completing this work he received another call, this time through the intercession of Humboldt. The gravity experiments made by Bessel at the Berlin Observatory could not be of any especial value, owing to the uncertainty of the altitude of Berlin above sea-level, which at that time was known only from barometric observations. Trigonometric leveling was now coming into great favor, especially when the precaution was taken to make reciprocal zenith-distance observations. So, when it was ordered by the general staff in 1835 that the altitude of Berlin above the mean sea-level at Swinemünde should be determined, the execution of the order fell upon Baeyer, who, with the assistance of Bartram, finished it during the same summer. The result obtained differs only by a few decimetres from that recently found by a line of geodesic levels. At Swinemünde a permanent mark was established, and annually for several years the height of this above mean tide was measured; these records many years later disproved the theory that the Baltic Sea had been subjected to a great change during the first half of this century in height.

He was placed in charge of the survey of the coast of the Baltic Sea in 1837, the triangulation for which he joined to that of the degree-measurement chain. This was carried up to annexation with the Danish work. In 1843 he was made chief of the trigonometric branch of the general staff, when he continued his great coast-survey, bringing the triangulation from Stettin to Berlin, and also connecting with Müffling's chain. These nets, together with Tranchot's and others, executed earlier for the purpose, formed the basis for the land-survey of the Prussian states. Baeyer thought that work done at different times and by various persons should be brought into harmony by all resting upon the same basis; to which end he measured

two bases, one at Berlin in 1846 and the other at Bonn in 1847. The results of the former were announced in 1849, but the necessity for reobserving some of the adjacent angles delayed the publication regarding the latter until 1876.

The coast-triangulation was so well executed that it was deemed advisable to utilize it in degree determinations by connecting it with the Russian system. This was done by Baeyer and General von Tenner from 1850 to 1851, with every precaution then known, including remeasurement of bases and a careful comparison of the standards. The difference in the total length of sixteen sides they had in common was only 0·505 metre.

His work occasionally overstepped the boundary-lines, establishing stations in other countries; these served as germs of larger growth, in many cases afterward nurtured by Baeyer's own hands. His advice was so frequently solicited, and when followed the results were so praised, as to induce him to prepare and submit to the Prussian Minister of War a memoir giving in detail a method for making a good map of Prussia. The principal improvement suggested, and afterward adopted, was in the more extensive use of triangulation, fixing in this way every point of importance, leaving but little intermediate ground to be located graphically.

His tastes for geodetic work were soon to be more fully gratified. Having passed rapidly through the lower grades, he was in 1858 made a lieutenant-general, and retired. It seems as though this eventual freedom to follow his own inclinations had in early life impressed itself upon him, for we find that in his work when he came to a station that at some future time might be of geodetic importance, he bestowed upon it especial care, supplementing the usual series of observations with those that would obviate the necessity of reoccupying it. Before indecision as to what should next receive his attention had become wearisome, Struve secured his co-operation in extending the Russian arc of longitude along the fiftieth parallel into Prussia. This he had in hand during 1858, making only astronomic observations, as it was his purpose to use the triangulation previously made. After several interruptions, owing to the withdrawal of the officers detailed to assist, he decided to make Rauenberg his central point, and to determine the direction of the chain by the azimuth of the line from this station to the Marien-Dom in Berlin—a line which now orients the entire Prussian survey.

The association with Müffling, Bessel, and Struve gave to Baeyer the incentive to connect and unify the excellent geodetic work of middle Europe; geographically, his native land occupied a favored place, and his government fostered the scheme. In 1861 the plan for a middle European degree-measurement, drawn up by Baeyer and sanctioned by the Minister of War, was approved by the emperor. At once the co-operation of the states that were to participate was re-

quested, and to show the importance of such an undertaking, he published a pamphlet on the "Size and Figure of the Earth," giving an account of the geodetic work up to that time, and outlining what remained to be done under the auspices of the proposed commission. The permanent commission held its first session in Berlin in 1864, with Baeyer as president—a young organization with a leader aged seventy. The Prussian Geodetic Institute, established in 1869, was also placed under the direction of Baeyer. In both institutions he took an active part, not only in the official routine, but in making astronomic observations and comparing standards until 1874.

Under his instructions, the observations of Bessel at Königsberg in 1826, and Schumacher at Guldenstein in 1829, with the pendulum, were repeated, to see if the length of the seconds pendulum had retained the same relation to the toise. No change was found, showing that no alteration had taken place in the toise from molecular action, as had been feared.

As a careful observer, his attention was always directed toward possible sources of error in his work, especially toward atmospheric refraction, and, as connected with it, the physics of the atmosphere. He utilized all data obtainable from leveling for deducing a formula in which the coefficient of refraction could be given as a function of time or meteorologic conditions. The elaborated formula was published in 1840, and with revisions in 1860. He also conceived the application of the converse principle, from which observations for refraction would reveal the condition of the atmosphere. In addition to his purely practical discussions he wrote several articles upon winds, and the solutions of spheroidal triangles. He was an active or honorary member of the leading scientific societies at home and abroad; many decorations were conferred upon him by various crowned heads. On the 8th of January, 1883, he celebrated the seventieth anniversary of his connection with scientific work. And on the 6th of November of the following year, in honor of his ninetieth birthday, the Academy of Sciences of Berlin sent a deputation to carry their congratulations and good wishes; the Geodetic Institute presented him with a bust of himself, and the emperor and crown prince sent their compliments.

He brought his interest in scientific work down to his death-bed, on which, two days before his end, he was listening to the report of operations that he had shortly before planned and started. On September 10, 1885, the inflammation of the lungs, from which he had suffered only a few days, proved fatal.

NOTE.—While preparing this, I received from Dr. Helmert, Baeyer's successor as President of the Prussian Geodetic Institute, his sketch of the scientific labors of Baeyer, an excerpt from "Vierteljahrsschrift der Astronomische Gesellschaft," Band 2, Heft 1, to which I am indebted for many facts of interest. A list of Baeyer's writings can be found in "Literatur der praktischen und theoretischen Gradmessungs-Arbeiten," an appendix to the report of the Permanent Commission for 1881. A revised edition of this valuable publication will appear in connection with the report for 1886.

CORRESPONDENCE.

"THE SAVAGERY OF BOYHOOD."

Editor Popular Science Monthly:

SIR: Under the above title an article appeared in your October number, against the conclusions of which I beg to enter my most emphatic protest. I regard this article as the more dangerous in its practical effects (for it is likely to be much quoted), because, with what is not true to fact, there is intermingled much with which every biologist will agree. Says the writer: "My own conviction is, that healthy boys under fifteen feel very little compassion for any suffering but that of their near relatives, their close friends, and occasionally their pet animals. Cruelty seems to be a fundamental fact in the nature of children. In view of the law of our development, which carries us along the path our ancestors have trod, how can we expect our boys to be anything else but cruel?" It is my conviction that these utterances are libels on child-nature, and as such deserve to be promptly repudiated. When the doctrine of evolution is made responsible for such views as these, I do not wonder that it becomes distasteful to persons of sensibility, who may not, however, have the requisite knowledge to enable them to see through the fallacies. Doubtless there is a certain proportion of boys of whom the statements of the writer in question may be true, but they do not constitute the majority even as things are now. Incidents like those cited by the writer do show how faulty and imperfect is our treatment of the mental and moral nature of children, and not that such conduct is natural to the healthy and normally developed youth. After having been a pretty close observer of children of both sexes for many years, I have been led to adopt views totally opposed to those advanced by the writer of "The Savagery of Boyhood." The child born in civilization, when neglected or ill-taught, may certainly be somewhat of a savage; and such he would remain, but for the education forced upon him by his surroundings in later life. With the great majority of children of both sexes there is, however, the natural tendency to regard the lower creation with interest, and a sympathy sometimes even ludicrous. The secret of the development of these feelings lies in explaining to a child, when still quite young, the nature of animals great and small, in a way it can understand, so as to bring out the fact that they are *like ourselves*—very like ourselves. To illustrate imperfectly by an example: A child of five years that had always been taught thus to regard the animal creation was amusing itself by watching a cockroach confined for the time under a tumbler. Presently several children of its own age came in to play. The cockroach escaped, and one of these "savages" promptly crushed it—precisely as it had always been taught by example to do. The first child burst into a flood of tears, and declared it wanted no more of such playmates. Inasmuch as I have known this child intimately for most of its lifetime, I think I should have been able to detect physical disease (which is the kind our writer refers to), but this child is neither specially precocious nor in any way diseased so far as can be discovered—and I am not without experience in making such discriminations. No, the "savagery" is the result of our own neglect or educational bungling. I regard the views of the writer of the article in question as especially pernicious, because they will tend to encourage parents and educators to put the blame upon Nature that should be laid at their own doors—or rather, perhaps, to acquiesce in a state of things that calls loudly for correction. Until adults realize that the lower animals are *fellow-creatures* in a fuller sense than at present, the teaching children get, with regard to their relations to them, must be very ineffectual. Fortunately, there is some literature that can be put into the hands of young children that will do good in this direction. I do not think most boys could read such works as those from the pen of Dr. Charles C. Abbott (e. g., "A Naturalist's Rambles about Home"), without losing—if they ever had it—what Mr. Johnson is pleased to call their "savagery" of nature; especially if perused under the guidance of an intelligent parent who himself really had any sympathy with our "poor relations." The doctrines of "The Savagery of Boyhood" remind me of certain others almost equally unfounded in nature, though less harmful, in regard to allowing children to carry on all their social life and amusements after their own crude notions. Do those holding such views consider that it can be shown, almost to a biological demonstration, that what each one of us is to-day is the resultant of all that has gone before in our own history and that of our ancestors? How shall we have well-balanced and order-loving men if we encourage children in disorder? The mischief of later years is largely the outcome of ill-directed activities in childhood. Would that we really believed that whatsoever an individual sows,

either as boy or man, that shall he also reap, holds of necessity of man's entire nature! Not to occupy too much of your space, Mr. Editor, I conclude by expressing the hope that the readers of the "Monthly" will not adopt the views expressed in "The Savagery of Boyhood," till they have some sounder basis for them than has yet been furnished.

T. Wesley Mills.

Physiological Laboratory, McGill College, Montreal, *October* 8, 1887.

TOLSTOI'S ASTRONOMY.

Editor Popular Science Monthly:

Sir: The great Russian novelist, Count Leo Tolstoi, in his powerful story, "Anna Karénina," makes a curious mistake in describing the phenomena of the heavens, which will do to put with those you have noted in regard to the moon. After describing with great beauty and fidelity to nature a spring day, he says (page 176, Crowell's edition, New York):

"It grew darker and darker. Venus, with silvery light, shone out in the west; and in the east Arcturus gleamed with his sombre, reddish fire. At intervals Levin saw the Great Bear. No more snipe appeared; but Levin resolved to wait until Venus, which was visible through the branches of his birch-tree, rose clear above the hills on the horizon, and till the Great Bear was entirely visible. The star had passed beyond the birch-trees, and the Wain of the Bear was shining out clear in the sky," etc.

Venus, when seen in the west as evening star, would, on the same evening, sink lower instead of rising higher. It is curious that Count Tolstoi, who is in general an accurate observer of Nature, and who shows, in this very passage, that he has watched the heavens on spring evenings, should make such a mistake. He has confused the apparent and real motions of Venus evidently.

Elisa A. Bowen.

September 20, 1887.

EDITOR'S TABLE.

AN ALLEGED ARGUMENT AGAINST EVOLUTION.

THE "Journal of Commerce" of this city has been occupying itself lately with the question of the origin of the human race; and, as the result of its studies and reflections, feels justified in pronouncing that "the development theory is refuted by all human experience." The main argument on which our contemporary relies to support this opinion is that there is no "organic tendency toward constant improvement and greater uprightness," that it is not natural for man to be good, and that he only attains to any moral excellence through unceasing struggle. No text-book in theology—so we are informed—is needed to tell us that the race is not attaining to moral goodness by the slow process of natural development; the conflict in every man's breast being sufficient to assure him that the ideal which he pursues is the original image of perfect righteousness that has been defaced by manifold transgressions. Such is the argument of our contemporary, stated, as nearly as possible, in its own words. We need hardly say that we are glad to find a paper like the "Journal of Commerce" presenting subjects of this character for the consideration of its readers; and we feel assured that it will be prepared to examine in a candid spirit the comments we propose to offer on the view above outlined.

In the first place, we would observe, the theory of evolution is one of a very wide compass; and, if it is applied with some degree of confidence to the history of morals, it is because, in so many other fields, it has proved itself the key to phenomena otherwise unexplainable. The language held by Professor Morse before the American Association for the Advancement of Science, and by Professors Roscoe, Newton, and others before the similar British Association, sufficiently proves in what light the doctrine of evolution is regarded by the most eminent scientific investigators of our day. The question, therefore, presents itself as to whether man's moral nature has been formed upon principles, and by a method, wholly different from those illus-

trated in every other domain accessible to human inquiry. Before we grapple with this question, however, it will be well to place before ourselves as clear an idea as possible of what man's moral nature is.

The moral nature of man, according to our understanding of the expression, is that part of the human consciousness which takes cognizance of, and is definitely affected by, *conduct*, as that term is employed both by Herbert Spencer and by Matthew Arnold. That there should be a sense for conduct is as natural as that there should be a sense for any other outward phenomenon; and, if so, we can readily understand that an individual may examine and criticise his own conduct just as he may examine and criticise his own personal appearance. The norm or standard in both cases—that is to say, whether conduct or physical structure is in question—is the same, namely, some assumed ideal suitable to the human race, and in a manner generalized from varying human characteristics. Nobody, so far as we are aware, aspires either to a virtue or to a beauty appropriate to any non-human race of beings. Enough for a man to be a man in the best sense; enough for a woman to fulfill the best type of womanhood. But this striving after a type, what does it imply? Our contemporary says that, so far as conduct is concerned, it implies the original creation of a perfect moral nature, which sin has marred, but of which a perpetual reminiscence lingers. Good! but how about the striving after physical beauty? Does that also imply the reminiscence of a lost perfection? Or does it merely imply a sense in the individual of that which constitutes the best expression of the species? We incline to the latter opinion, and we think a similar answer might be given to the question as to the striving after a moral ideal.

The fact should not be lost sight of that our ideas in regard both to beauty of conduct and to beauty of form are very greatly controlled by habit and tradition. The standard of physical beauty varies from country to country, so that what inspires admiration here may be regarded as far from attractive there; and the same may be said of the standard of virtue. What is deemed most worthy of imitation in one age or clime may be regarded with positive disapproval under changed conditions of time or place. The very words "moral" and "ethical" teach us a lesson under this head; since the essential meaning of both, if we revert to their etymology, is neither more nor less than "customary." The first notions of morality were therefore based wholly on custom; and only as reflection developed, and as the contact of tribe with tribe and nation with nation gave the opportunity of comparing custom with custom, did the notion of morality enlarge and purify itself. The red Indian of former days would strive to harden himself against physical suffering, and to deaden in his heart any stirrings of compassion for a fallen foe. Are we to suppose that the original typical or ideal human nature was one, the main features of which were physical endurance and remorseless cruelty? If not, the argument drawn from the sense of struggle or conflict must fall to the ground; for undoubtedly every individual Indian had to *strive* in order to bring himself up to the true heroic level, as understood in his tribe. The need for effort to attain any moral ideal, whether that of the red Indian or that of the most public-schooled inhabitant of Massachusetts or New York, seems to us to be strictly comparable and analogous to the need for educational effort of other kinds. The family, the tribe, the race, acquire knowledge, habits, and principles of one kind or another, which every new-born individual must grow up into, on pain of social failure and probably of early

extinction. By the observation, the thought, the suffering of many, experience is gained, and by self-control and self-direction that experience is applied to the government of life. If the individual, with his narrower personal experience, wishes to share in the general fund of wisdom and morality acquired by the social aggregate to which he belongs, he can only do it by conscious effort. The customary morality of the community is impressed upon him, in the first place, by public opinion, and it is left to him to check his purely individual impulses in the degree necessary for realizing (perchance transcending) the social ideal. It may further be observed that the ideal toward which the individual strives is identical with the standard of conduct which he is disposed to exact from his neighbor. Thus, to each man, conscience is the echo of the demands he makes upon others in the matter of conduct. Every man wants truth and justice and kindly help when necessary from his fellow-man; why, then, should he not yield them in return? How can he fail to at least profess a conformity with the standard he sets up for others? And if he continually professes to acknowledge that standard, how can he fail to strive more or less to adjust himself to it? If this involves conflict, on the one hand, it promises escape from conflict on the other—the conflict between a man's inner and outer self, between his professions and his practice.

We are thus very naturally led to see that the sense of effort in the individual is in no way incompatible with the existence of general tendencies by which human conduct is raised to successively higher levels. We scarcely gather from our contemporary's article above referred to that he has taken any pains to familiarize himself with the arguments of the evolutionist school. If he will not shun the effort needed for this purpose, but will read with attention Herbert Spencer's "Data of Ethics," or even so brief a treatise as Mr. Fiske's "Destiny of Man," we think he will find himself confronted with indubitable evidence that there has been an evolution in morals and in thought as well as in physical structure; and that this has been carried on, in the main, independently of mere individual volition. What the individual has to do is to keep up with the procession, and take a front rank in it if he can; he does not make the procession, nor can he greatly accelerate or retard the speed of its movement.

We might, indeed, turn our contemporary's argument against him by asking how it is, if a certain moral constitution was imparted to man at the outset, that so much struggle should be involved in getting back to it. Reversion is generally, if not always, an easy process; the difficult thing is to add something to the ancestral inheritance. Evolutionists say that, if wrong-doing is easier than right-doing, it is because wrong-doing implies falling back on the more deeply implanted primitive instincts, and right-doing the exercise of more recently acquired and morally higher instincts. To be sensual merely requires a yielding to appetite; to be unjust, a compliance with some selfish motive; to be cruel, the indulgence of the instinct for destruction. Primitive man, wherever we find him, is sensual, unjust, and cruel; and the hoodlums and ruffians of our great towns show to-day the same characteristic. If, then, men have to struggle in order to be moral, in order to attain to "righteousness," it is because the higher moral attributes are of comparatively recent development, and not as yet as thoroughly worked into human nature as the primitive, self-regarding instincts. We are glad to have had this opportunity of discussing an important and interesting question; and we trust the "Journal of

Commerce" may find frequent occasion in future to introduce similar philosophical themes to the notice of its readers.

TRUTH AND ITS PURSUIT.

THERE is a well-known saying of Lessing's, according to which the pursuit of truth is rated as of higher value, and more to be desired, than the truth itself. Sir Henry Roscoe quoted this sentiment in his recent inaugural address to the British Association; and the London "Spectator," in a thoughtful article—all the "Spectator's" articles, we may say in passing, are thoughtful—raises the question as to whether Lessing's "paradox," as it calls it, conveys as much truth as is commonly supposed. It points out that, in scientific matters generally, the truths discovered are of value to thousands who take no part, and are incapable of taking any part, in bringing them to light; and that, even in regard to moral questions, it is impossible to conceive of the pursuit of truth having any value apart from a strong conviction of the value of the result to be arrived at. If the result is not itself of value, or at least is not believed to be of value, then there is nothing ennobling in pursuing it. If, on the other hand, the result is of value, and so far lends significance and dignity to the pursuit, how can we say that the mere pursuit, cut off from all hope of an actual realization of the truth, is of more value than the truth itself? How, indeed, can we regard it as having any elevating effect whatever?

All that can be said in reply to this reasoning, so far as we can see, is that we should not demand from Lessing's paradox more than, as a paradox, it is able to render. The function of a paradox, as we conceive it, is to draw attention to some aspect of truth which is in danger of being overlooked, and to do this by piercing below the level at which our thought ordinarily rests. Thus, in regard to truth, it is natural to think only of results, and to regard as failure all that does not lead to results. Here Lessing steps in to tell us, and truly, in our opinion, that more valuable than the discovery of any particular truth is the tendency of the mind toward truth in general. Truth, when realized, increases the resources of the human mind, or, as we may say, the intellectual capital of the human race. It is like the dollar won by honest labor, and henceforth available for the production of further capital. But, if such is the character and such the value of realized truth, what shall we say of the effort, of the concentration of mind and purpose, that led to its discovery? We can surely say that the discipline thus gained is often of far greater value, at least to the individual, than the final result of his labors. Thus, also, the dollar gained may really be of far less account than the qualities developed in the gaining of it. Of course, it may sometimes be the case, on the other hand, that comparatively slight labor and thought—mere accident even—may sometimes result in the discovery of some truth of the highest importance; just as one might, with slight or no searching, light upon a source of unlimited material wealth. From this point of view we have to consider what human life would be if all our discoveries came to us in this way without effort, and without any need for the self-control and patient industry which the serious pursuit of truth now involves. In trying to form a conception of this we seem to escape from all bounds of law, and to find ourselves in a region where the stable landmarks of human existence have disappeared. Work is man's discipline on this earth; and, without that discipline, he would be a poor, wayward, worthless creature, if, indeed, we can conceive him as existing as an intellectual being at all.

Lessing's paradox, then, presents us with an impossible situation. The choice between truth and the pursuit of truth could not conceivably be offered to any

one; nor could such a thing be as an ever-fruitless pursuit of truth; nor yet such a thing as a system of truth grasped by the human mind independently of all previous attempts toward its construction. The very sense that truth is truth comes from a perception of harmony between an attained result and a set of circumstances or phenomena of which it affords a *desired* explanation. Had the explanation never been desired and sought after, no interest or value could possibly attach to it. While, however, the situation that Lessing's words suggest is an impossible one, our attention is none the less roused by it to the fact that, not by outward results alone is the value of human effort to be gauged, but also, and perhaps mainly, by the inward growth of mind and character which is its accompaniment. We learn, also, that to be loyal to the truth is of more account than to be merely successful in formulating it: in a word, that the interests of the human spirit, or, perhaps more correctly, of the intellectual and moral consciousness, are supreme, and that the great flow of significance, so to speak, is from within the human consciousness to the outward conditions, and not from without inward.

LITERARY NOTICES.

THE ELEMENTS OF POLITICAL ECONOMY, WITH SOME APPLICATIONS TO QUESTIONS OF THE DAY. By J. LAURENCE LAUGHLIN. New York: D. Appleton & Co. 1887. Price, $1.40.

IF the numerous school-books that appear in our time were all they ought to be, the education of the young, so far as books can aid it, would be amply provided for, but unfortunately such is not the case. In the mathematical and physical sciences, indeed, and in classical literature, there are many good text-books; but in the sciences that treat of mind and society the works of real merit are comparatively few. The reason of this scarcity is twofold: in the first place, these sciences are not so well developed as physics and mathematics and classical philology, and there is less agreement about the method of studying them—the mutual opposition of the philosophical and historical schools being specially conspicuous; and, secondly, the close connection of the mental and social sciences with the great disputed questions of politics and religion render the pure scientific treatment of them difficult. Hence we have at present but few satisfactory treatises on political, economical, or ethical subjects.

This work by Professor Laughlin, however, is distinctly superior to most of the current writings on economical themes, and seems to be well adapted to educational use. It makes no pretension to originality in doctrine or theory; but undertakes to give the student, in as simple a form as possible, the leading thoughts and conclusions of the great economic writers. The author remarks in his preface that "the public questions of our day in the United States are deeply affected by economic considerations, and yet the training of mind adequate for an intelligent decision upon economic problems has been very slight." Yet he thinks that "public questions and the economic principles which underlie them can, if properly presented, be understood by the average American youth whose education is restricted to the high-school or the academy." For such students, then, and with such an aim, Professor Laughlin has written, and with much success. His arrangement is good, his style clear, and his views, in the main, such as are best established. He has avoided controversy, so far as possible, evidently thinking it unsuitable to an elementary work. If we were to offer a criticism on the author's method, we should say that he had confined himself a little too strictly to the deductive or philosophical method of the English writers, with too little attention to the historical and comparative method; for, though we have no faith in the historical method as a substitute for the other, it nevertheless has its uses.

Professor Laughlin's book is divided into two parts: the first, treating of the principles of the science; the second, of their application to some of the political and industrial problems of the day. In an introductory chapter he distinguishes the subject of the science from those of ethics, politics, and

other branches of science or practice with which it is liable to be confounded, and lays down the principle that "political economy deals only with questions connected with wealth and with the satisfaction of material wants." It "does not say what is right or wrong, or how a people should be governed; but it attempts to show what the rules are that control the production, exchange, and distribution of all the wealth which we see in the wonderful industrial system about us." It is refreshing, amid all the confusion that so widely prevails between economical and ethical truth, to find an economist with so clear a grasp of his subject. He distinguishes between "immaterial wealth," such as a speech or a song, and "material wealth," which has a permanent character; and defines material wealth as "some transferable thing for the enjoyment of which we are willing to undergo a sacrifice." He gives the usual account of the agents of production, and then passes to the subject of exchange. He defines value as ratio of exchange, and from another point of view as purchasing power. Cost of production he holds to consist in the sacrifices made by the different classes engaged in production; and on this subject he is careful to avoid the mistake made by the earlier writers of considering economic phenomena too much from the standpoint of the capitalist. On the subject of demand and supply, he adopts in the main the views of Cairnes, as he also does in regard to the wages of different classes of laborers. On the subject of distribution, now so hotly debated, Professor Laughlin takes conservative ground, holding that "the proportional shares of labor and capital out of the product will depend upon the relative scarcity and abundance of labor and capital," and that "the productiveness of a country's industries determines whether the general level of the wages shall be high or low." He takes conservative ground, also, in regard to labor-unions, approving them in some respects, and disapproving them in others; and he devotes a special chapter to "the industrial manager," showing the important place which he holds in the industrial system of the present day.

In treating of the applications of economic principles, the author discusses socialism, free trade, and protection, money questions, the labor problem, and other topics, indicating briefly the bearing on each of the doctrines advanced in the earlier portion of his work. On the subject of the tariff he gives the arguments on both sides, but is himself evidently a believer in free trade. In regard to bimetallism he reiterates the views that he had already more elaborately stated in a separate work. He opposes socialism, of course, and teaches that the welfare of the laboring-classes can only be secured by their own moral and intellectual advancement. He strongly deprecates state interference, and favors co-operation in all its forms.

The book is an excellent elementary presentation of a difficult subject of growing interest and importance, and as such it deserves a place in both public and private schools.

HISTORY OF THE PACIFIC STATES OF NORTH AMERICA. By HUBERT HOWE BANCROFT. Vol. XXXI. POPULAR TRIBUNALS. Vol. I. San Francisco: The History Company. Pp. 749. Price, $5.

THIS volume stands apart from the other members of Mr. Bancroft's historical series. It has a character of its own, as do the events to which it relates. They have hardly a parallel in history. The volume particularly relates to those voluntary courts or self-organized associations of citizens for the administration of justice and the avenging of wrongs which, in some of their forms, have marked the society of the frontiers during the whole of the history of the settlement of our country; which were prevalent throughout California in the early days of the American settlement; and which found their most remarkable exemplification in the vigilance committees of San Francisco. Mr. Bancroft endeavors to draw a distinction between the vigilance movement in California and all other exhibitions of popular justice which are recorded. He does not find anything exactly like it in the public uprisings of which ancient and modern history furnish examples; and to his view it was very widely different from the mob law, lynch law, regulators' law, etc., with which it is too easy to associate it in classification. "In some respects," he says, "they are diametrically

opposed in principle and in purpose. The vigilance committee is not a mob; it is to a mob as revolution is to rebellion, the name being somewhat according to its strength. Neither is a tumultuous rabble a vigilance committee. Indeed, prominent among its other functions is that of holding brute force and vulgar sentiment in wholesome fear." It is founded on a principle, and this is that "the people, or a majority of them, possess the right, nay, that it is their bounden duty, to hold perpetual vigil in all matters relating to their government, to guard their laws with circumspection, and sleeplessly to watch their servants chosen to execute them. Yet more is implied. Possessing this right, and acknowledging the obligation, it is their further right and duty, whenever they see the laws which they have made trampled upon, distorted, or prostituted, to rise in their sovereign privilege, remove such unfaithful servants, lawfully if possible, arbitrarily if necessary. . . . When law fails—that is to say, when a power rises in society antagonistic at once to statutory law and to the will of the people—the people must crush the enemy of their law or be crushed by it. A true vigilance committee is the expression of power on the part of the people in the absence or impotence of law." . . . As defined in this book, "the principle of vigilance takes its place above formulated law, which is its creature, and is directly antagonistic to the mobile spirit which springs from passion and contemptuously regards all law save the law of revenge." As may be inferred from these quotations, Mr. Bancroft is rather warmly in favor of California "vigilance," and appreciates highly the fruits which San Francisco has reaped from the exercise of it. He has obtained the materials for the historical record of its operations from first hands. Besides printed books, manuscripts, and the several journals of the period advocating both sides of the question, he secured all the archives of the San Francisco Committee of Vigilance of 1851, and had free access to the voluminous records and documents of the great committee of 1856. Further than these, he personally questioned the actors in the scenes who were living, and, after a little difficulty in overcoming the reserves of some of them, obtained such information as they could give him. The questioning, he thinks, was done at a most opportune time. "Ten years earlier, the actors in these abnormal events would, on no account, have divulged their secrets; ten years later, many of them will have passed away, and the opportunity be forever lost for obtaining information which they alone can give." The story is of the most fascinating character; and did not require, to intensify its interest—which is marred rather than heightened by it—the sensational style, hardly befitting a sober history, which the narrator has employed in some parts of his account. About four hundred pages of the volume are taken up with the history of the San Francisco Vigilance Committee of 1851; the rest is devoted to the operations of the "country committees of vigilance," and of popular tribunals in other States and Territories of the West, British Columbia, and Alaska.

ENGLISH HISTORY FROM CONTEMPORARY WRITERS. EDWARD III AND HIS WARS. Arranged and edited by W. J. ASHLEY. THE MISRULE OF HENRY III. Selected and arranged by Rev. W. H. HUTTON. New York: G. P. Putnam's Sons, 1887.

THE study of history in the usual way, though it gives a comprehensive view of the subject in the language of our own time, has nevertheless its drawbacks. However scientific the historian's work may be, and however entertaining his story, it does not give us that vivid and characteristic view of an age that we get from the contemporary writers. A consciousness of this fact has led to the preparation of this series of volumes on the history of England. They consist entirely of extracts from writers who lived in the times treated, with only such brief notes and introductions as are necessary to explain their significance and connection. The authors from which the compilation is made are of course the mediæval chroniclers, such as Froissart, Matthew of Paris, and others, while laws and other public documents are cited as occasion requires. The volumes now before us treat of the thirteenth and fourteenth centuries, and others are projected covering the whole period of mediæval and Renaissance history. The series is under the editorship

of Mr. F. York Powell, the different volumes being prepared by various writers.

The volume on Edward III is necessarily very much occupied with the wars with France and Scotland, yet the social and religious affairs of the country are not neglected, and in the "Misrule of Henry III" these subjects are the principal ones. This latter volume exhibits in a striking manner the tyranny and extortions of the Papacy during the thirteenth century, while the Statute of Provisos, the Statute of Præmunire, and other measures of Edward III's reign, illustrate the means taken to counteract the evil. The fearful epidemic of the black-death and its effects claim attention, and are briefly but vividly related. One of the most striking effects of this plague was a great rise in wages, owing to the reduction in the number of laborers, and the chroniclers relate the attempts that were made by law to keep wages down. Thus, we read that "the king sent proclamation into all the counties that reapers and other laborers should not take more than they had been accustomed to take, under the penalty appointed by statute. But the laborers were so lifted up and obstinate that they would not listen to the king's command, but if any one wished to have them he had to give them what they wanted, and either lose his fruit and crops, or satisfy the lofty and covetous wishes of the workmen." These passages are curious reading now, as are also those denouncing the taking of interest; but they show in clear light the supremacy of natural law.

Such works as these can not supply the place of the ordinary historical treatises, since they do not furnish a complete and connected view of the periods to which they relate. But they are very interesting and valuable, as giving what may be called an interior view of the times and subjects of which they treat; and students of history will look with interest for the remaining volumes of this series.

PRINCIPLES OF ART. By JOHN C. VAN DYKE. New York: Fords, Howard & Hulbert, 1887. $1.50.

THIS book is an elementary treatise on the history and theory of art. It makes no pretension to originality or to scientific profundity, but is intended for the mass of people that are interested in the subject. The discussion chiefly relates to the arts of form and color—architecture, painting, and sculpture; the other fine arts, such as music and poetry, being introduced only for purposes of illustration. The book is divided into two parts, the first of which deals with the history of art, the second with its philosophy. The author's views of the development of art are substantially those generally held by writers of the historical school. He regards the art of a nation as the product of its civilization, and thinks that "nothing can record so truly the nature of a people or a country's civilization as its art" (page 13). He holds that "art is what its age and its environment make it" (page 173). "The artist lives in his own time, and seldom ahead of or behind it. If he is striving toward the unattainable of the future, there is some impulse of his age that urges him on. If he goes back to imitate an art of the past, again some tendency of his time promotes it. Whichever way he turns, and whatever he may do, the circumstances of his surroundings rule him unconsciously" (page 13). These extracts show the author's views of artistic development; and the historical part of his work is an attempt to apply these principles to the facts of art-history. Several pages are devoted to the theory of art, but we have no space to discuss or even to explain the author's views. As regards the art of the present day, he thinks its leading characteristic is the expression of individual tastes, a view which he illustrates by numerous examples.

THE ESSENTIALS OF PERSPECTIVE, WITH ILLUSTRATIONS BY THE AUTHOR. By L. W. MILLER. New York: Charles Scribner's Sons. Pp. 107. Price, $1.50.

THE author calls this little book "The Essentials of Perspective," because it seems to him that it contains as much information about the science of which it treats as the artist or the draughtsman ordinarily has occasion to make use of. He has aimed to produce a work exhaustive enough to present the subject adequately, and yet be as free as possible from the technical difficulties which the unscientific mind will encounter in the profounder treatises. Some unessential things are left out, in the effort to make clear the really important truth.

The illustrations are given with the aim to connect the study with the work of the artist, rather than for use as diagrams, by which to demonstrate abstractions; and they are of precisely the same character as those which the author has used for many years in teaching perspective from the blackboard. The successive chapters of the book treat of "First Principles," "The Horizon," "Measurement by Means of Parallels," "Of Diagonals" and "Of Triangles," "The Perspective of Curves," "Methods," "Shadows," "Reflections," and "Cylindrical, Curvilinear, or Panoramic Perspective."

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INSTITUTES OF GENERAL HISTORY. By E. BENJAMIN ANDREWS. Boston: Silver, Rogers & Co. 1887. $2.

THIS is a rather peculiar book. It is by no means an elementary work; on the contrary, a student just beginning the study of history, would not be able to understand it, so much is taken in it for granted. But by one who already has a knowledge of the outlines of history it will be found both interesting and instructive. It is rather a series of historical essays than a regular history, and, while making no pretensions to originality, it presents in a brief form the conclusions of the leading writers on most of the main events of the past and the contributions of the various nations to the civilization of the world. English and American history are neglected on the ground that these subjects are taught in our schools by themselves. The book is broken up into short paragraphs, each followed by a mass of notes treating matters of a more specific character than those mentioned in the text.

Professor Andrews opens his work with a brief discussion of the nature and method of history, and considers the question whether history is a science. To this he gives an affirmative answer, quoting Mill's remark that "any facts are fitted in themselves to be a subject of science which follow one another according to constant laws, although those laws may not have been discovered nor even be discoverable by our existing resources." He regards historical science, however, as in an inchoate condition, and its laws as but very partially known; and he defines it as "the science of humanity viewed upon its spiritual side, and in course of evolution." Having thus stated his conception of history and the method of studying it, Professor Andrews proceeds to consider first the character of the civilization of the old Eastern nations, and then that of Greece and Rome. The classical period receives but scant treatment, apparently because it is usually taught in the schools as a separate study. Then, having sketched the character of the Roman Empire and Church, he takes up the history of modern Continental Europe, to which the greater part of the volume is devoted. This portion of the work is fuller of detail than the earlier parts, and gives a good though very condensed outline of feudalism, the Renaissance and the Reformation, the Thirty Years' War, the French Revolution, and the rise of the new German Empire. Each chapter is preceded by a bibliography of the subject of which it treats, so that the real student of history will know where to go for fuller information. The utility of such a book for educational purposes must necessarily be determined by experience; but to general readers it will be of value both for reading and for reference.

INDUSTRIAL EDUCATION. A GUIDE TO MANUAL TRAINING. By SAMUEL G. LOVE. New York: E. L. Kellogg & Co. 1887. $1.75.

THE subject treated in this volume is one of great and increasing importance. The keen competition of industrial life, and the greater skill now demanded of manual laborers, as compared with those of former times, make it necessary for all who can to learn some trade or profession; while at the same time the want of any regular system of industrial training, and the unwillingness of the labor unions to permit the taking of apprentices, render it often difficult for a young man to learn the trade to which he inclines. Under these circumstances it has been proposed to establish schools of industry for the express purpose of teaching trades, and also to introduce some system of manual training into the public schools. Special industrial schools have been established in some cases, and have proved successful; but how far industrial work can be advantageously taught in the public schools is yet an unsolved problem.

Any book, therefore, giving an account of experiments in this direction will be welcomed by all persons interested in the subject; and such a book we have now before us. The author, who has been for some years superintendent of public schools in Jamestown, New York, in it gives an account of his introduction of manual training there, together with a detailed exposition of the system of training itself. Mr. Love is, of course, an enthusiastic advocate of industrial training, and a firm believer in its great usefulness. He holds that "it ranks in importance with the study of numbers or language, in the benefits it confers on its recipients." He notes the fact that some children dislike books, while they are fond of activity; and such children, he says, are made more interested in their school-work by the introduction of manual exercises. The system was introduced into the Jamestown schools on a small scale in 1874, and has been largely extended since, with the approval of the school authorities and of the people of the town.

The greater part of Mr. Love's volume is devoted to an exposition of the exercises that are practiced in the Jamestown schools, the subject being illustrated by a great number of diagrams. In the lower grades the exercises are the same for both boys and girls, and are of a very simple character, such as building with blocks, slat-plaiting, paper-folding, mat-weaving, etc. In the grammar and high schools they consist of carpenter-work for the boys, sewing and cooking for the girls, and printing for both sexes. And here we see one of the difficulties that the system has to contend with—that of introducing a sufficiently diversified industry. Every girl should know something of cooking and sewing, though these things ought to be taught her at home; but very few boys can be either carpenters or printers, and, though a little knowledge of carpenter-work may be useful in some other industries, this can hardly be said of printing. More boys will become farmers than anything else, and it is hard to see how farming or any branch of it can be taught in the public schools. We make these remarks not by way of criticism, but to point out one of the difficulties attending the introduction of manual training. Meanwhile, a work like this that shows experimentally how to overcome any of those difficulties will be welcomed by all who are interested in the subject.

A HISTORY OF THE NEW YORK ACADEMY OF SCIENCES (formerly the Lyceum of Natural History). By HERMAN LE ROY FAIRCHILD, Recording Secretary. New York: Published by the author. 1887.

THIS book owes its origin to a vote of the Academy, passed in June, 1886, authorizing and requesting the secretary to prepare such a manual. It was intended at first to make a short paper that might be included in a volume of the Academy's "Transactions"; but the author found an unexpected amount of material, and so expanded his essay to a volume of two hundred pages. The work has been approved by the Council of the Academy, and is now published in a limited edition of five hundred copies. It gives an interesting account of the origin of the society, which occurred in February, 1817, though the Lyceum, as it was then called, was not chartered until the next year. A list of the original members is given, and also a list of the present members. The progress of the society is duly recorded, separate chapters being given to the subjects of the library, collections, and publications, and biographies are given of several of the leading members. The author remarks that "the resident membership of the society has never been large," a fact which he attributes to the absorption of the people of the city in commercial affairs, and their consequent inattention to pure science. It is gratifying to learn, however, that the number of members at the present time is larger than ever before, and there is reason to hope that the American people will ere long give more earnest attention to science. The book is well printed, and will be welcome to all members and friends of the Academy.

BODYKE: A CHAPTER IN THE HISTORY OF IRISH LANDLORDISM. By HENRY NORMAN. New York: G. P. Putnam's Sons. 1887.

THIS work is an account of the eviction of several families of Irish tenants at Bodyke for non-payment of rent. The author was an eye and ear witness of much that he records, and seems to have taken consider-

able pains in studying up the facts. The greater part of the book consists of dispatches sent to the "Pall Mall Gazette," and published in that and several other papers; but some of the chapters are now published for the first time.

THE EFFECTS OF BEER UPON THOSE WHO MAKE AND DRINK IT; Real and Imaginary Effects of Intemperance; The System of High Licenses; Liquor Laws of the United States; Colonial Liquor Laws; Thoughts on International Temperance Meeting at Antwerp, 1885; Solution of the Temperance Problem proposed by the Government of Switzerland; and Alleged Adulterations of Malt Liquors. By G. THOMANN. TWENTY-SEVENTH BREWERS' CONVENTION, HELD AT BALTIMORE, 1887. New York: United States Brewers' Association, 1884–'87.

NEW YORK STATE BOARD OF HEALTH REPORTS ON EXAMINATIONS OF BEERS. New York: The State, 1886.

THE pamphlets named at the head of this article are issued by the Brewers' Association, with the declared purpose of promoting temperance by substituting the use of beer for spirituous liquors. The Association has a literary bureau, which is engaged in disseminating the doctrine, held by many other people besides brewers, that the best way to promote temperance is to extend the use of the weaker liquors and restrict that of the stronger ones. Accordingly, it advocates high taxes on distilled liquors, and the removal of the taxes now imposed upon ale and beer. The various pamphlets before us are mostly prepared by Mr. Thomann, the manager of the bureau, or under his supervision, and treat of various aspects of the subject under discussion. Some of them are designed to combat certain assertions and arguments of the prohibitionists; others are devoted to examining the effects of excise and other laws that have been enacted by different governments in relation to liquors. Those on the liquor laws of this country, contain a large amount of information tending to show that restrictions on the sale of malt liquors lead to a larger consumption of the products of the still.

Perhaps the work most important to the brewers' argument is that upon the effects of beer upon those who use it freely. It opens with a quotation from a total-abstinence writer, to the effect that beer inevitably produces various diseases, disorders of the liver and the kidneys being specially insisted on. Allusion is also made to the fact that one or two life-insurance companies had come to the conclusion that insuring the lives of habitual beer-drinkers was too risky to be advisable. To these facts and assertions, Mr. Thomann replies, first, by citing the opinion of certain physicians to the opposite effect, and then goes on to give some statistics relating to the health and longevity of the workmen in the breweries of New York and its vicinity. The brewers of this and the neighboring cities have a benevolent association for assisting sick and disabled workmen, and this association has established a system of medical supervision and examination which has collected facts regarding the health of the workmen generally, and the cause of the deaths occurring among them. The men have the privilege of drinking without cost all the beer they want, and consume an average of ten pints a day; yet, according to the statistics that are given, the death-rate among them is less than that of the generality of city residents as given in the United States census. In reply to the charge often made that beer is adulterated, Mr. Thomann cites the report of the New York State Board of Health to the effect that the four-hundred and seventy-six samples of malt liquors examined by them contained no deleterious ingredient whatever. These pamphlets will be sure to attract the attention of all interested in the subject of temperance, and may lead to a renewed discussion of the whole question of prohibitive and restrictive legislation.

BULLETIN OF THE PHILOSOPHICAL SOCIETY OF WASHINGTON. Vol. ix, for 1886. Washington, 1887.

AT the annual meeting of this society for 1886, papers were presented on a variety of topics, including even a phonetic alphabet. The Charleston earthquake was the subject of a long discussion, and there were also papers on other geological topics. A communication was presented on Lieutenant Lockwood's polar expedition, showing that that explorer had penetrated to a point nearer the north pole than any one

else. There was also a paper, which led to some discussion, on the origin and antiquity of certain social customs, such as bowing and kissing. The communication most interesting to the general reader was the address of the president, Dr. John S. Billings, on "Scientific Men and their Duties." Dr. Billings defines a scientific man as one "who uses scientific method in the work to which he specially devotes himself; who possesses scientific knowledge, not in all departments but in certain special fields." A man of science, on the other hand, is "a man who belongs to science peculiarly and especially, whose chief object in life is scientific investigation, whose thoughts and hopes and desires are mainly concentrated upon his research for new knowledge." He does not, however, agree with the view often expressed that the pursuit of knowledge for the mere pleasure of knowing is the true business of the man of science. On the contrary, he holds that the duty of men of science is to promote the welfare of mankind, and not merely to gratify personal curiosity. He discusses the question of the adaptability of government officers for scientific work, approving their employment in such work, though admitting that it has its drawbacks. In closing, he notes the fact that science has not yet furnished a satisfactory basis for morality, and makes some interesting comparisons between the science of the West and the religion and philosophy of the Orient.

FEDERAL TAXES AND STATE EXPENSES. By WILLIAM H. JONES. New York: G. P. Putnam's Sons. 1887.

THE author of this book is an advocate of a plan that has been advanced for distributing the proceeds of the United States tax on liquors and tobacco among the several States, the same to be devoted to paying the expenses of the State governments. The United States stand alone among the nations of the earth in having a public revenue so large that they don't know what to do with it; and manifold are the schemes that are brought forward for getting rid of it. One of the strangest of these is that which is advocated in this volume. Most people would regard it as unconstitutional; at all events, its adoption would be a great departure from the hitherto uniform practice of the Government. Mr. Jones, however, is a firm believer in it; and those who wish to know what can be said in its favor will find it in his pages.

THE GAME OF LOGIC. By LEWIS CARROLL. London and New York: Macmillan & Co. Pp. 96. Price, $1.

WITH each copy of this book is given an envelope, containing a diagram on a card, with nine counters. The diagram represents in its several divisions different classes of propositions; the counters are intended to mark the particular kinds of propositions, etc., which are to be employed in the problem at the moment seeking solution. The whole is designed to afford a graphic illustration, with tangible symbols, of the logical processes of drawing conclusions from premises. The game requires the counters to be of two colors, say four of red and five of gray, and may be played by one or more players.

ELEMENTARY TREATISE IN DETERMINANTS. By WILLIAM G. PECK. New York and Chicago: A. S. Barnes & Co. Pp. 47. Price, 75 cents.

AN acquaintance by students with the elementary principles of determinants being demanded by recent advances in mathematics, this book was prepared for the use of a class about to enter upon a course of modern co-ordinate geometry. It is a work in pure mathematics, the value of which can be adequately estimated only by experts in that department of the sciences.

SIXTH ANNUAL REPORT OF THE UNITED STATES GEOLOGICAL SURVEY TO THE SECRETARY OF THE INTERIOR: 1884–'85. By J. W. POWELL, Director. Washington: Government Printing-Office. Pp. 570.

THE topographical survey of the United States was extended, during the year covered by this report, over an area of 57,508 square miles, at an average cost of about three dollars per square mile. The results of the survey are to be embodied in maps, which will be published in scales of (approximately) one, two, and four miles to the inch; and is to be engraved in sheets, of which the unit will be one square degree; so that the maps of the different scales will require, respectively, sixteen, four, and one

sheets, for each square of one degree of longitude and one of latitude. The organization of the survey includes five paleontological laboratories, in which the fossils collected by the geologists in the field are described and reported upon; a chemical laboratory, laboratories of physical research and lithology; a division of mining statistics, and a division for preparing illustrations for the reports. The general geological work is organized into divisions of glacial; volcanic; Appalachian archæan; Lake Superior archæan; the areal, structural, and historic geology of the Appalachian region; the Yellowstone Park; and two mining divisions. The appointments to positions in the survey are made, on recommendation in case of persons of recognized scientific reputation in their several fields, and through civil-service examination for younger men. The work of each division of the survey is represented in the special report of its chief. A conception of the general character of the work, as a whole, may be gained from a view of the "accompanying papers." They are "Mount Taylor and the Zuñi Plateau," by Captain Dutton; "The Driftless Area of the Upper Mississippi Valley," by T. C. Chamberlin and Rollin D. Salisbury; "The Quantitative Determination of Silver by Means of the Microscope," by J. S. Curtis; "Seacoast Swamps of the Eastern United States," by Professor N. S. Shaler; and "Synopsis of the Flora of the Laramie Group," by Lester F. Ward.

FORTY-FIFTH ANNUAL REPORT OF THE BOARD OF EDUCATION OF THE CITY OF NEW YORK. New York: Hall of the Board of Education. Pp. 271.

THE whole number of children taught during the year, including the "corporate schools," was 304,758, and the average attendance, 153,643; while 3,998 teachers were employed. The average cost of instruction per pupil was $15.49½ in the primary departments and schools, and $29.80 in the grammar-schools. Corporeal punishment being prohibited, the severest penalty that may be inflicted is suspension or expulsion; and the efficiency of the system is claimed to be apparent in the constant diminution of the number of suspensions. While the subject of industrial education in the public schools has been under consideration, no conclusion has been reached upon it; but the city superintendent has been directed to make investigations upon it for advising the board as to the best action to be taken in the matter. The thoroughness of the drill and discipline of the common schools is exemplified by the fact that it requires but a single day to add, without confusion or disorder, six hundred new students to the classes of the college. The question of the introduction of manual training into the schools has engaged attention, but it has been deemed wise to proceed slowly. A committee has reported favorably, and advised that it be introduced at an early date. Manual instruction is, however, already in operation in the City College, where three workshops have been fitted up, with tools for various kinds of work in wood and metal; practical laboratories in chemistry and physics have been furnished; facilities are given for investigations in natural history; and advanced work is done in industrial drawing.

JOHNS HOPKINS UNIVERSITY STUDIES IN HISTORICAL AND POLITICAL SCIENCE. Fifth Series. Nos. I and II. THE CITY GOVERNMENT OF PHILADELPHIA. By E. P. ALLINSON AND BOIES PENROSE. 50 cents. No. III. THE CITY GOVERNMENT OF BOSTON. By J. M. BUGBEE. 25 cents. Baltimore: The University. 1887.

THE best mode of governing cities has been for many years one of the leading questions in American politics; and the problem is by no means solved even yet, notwithstanding the many experiments that have been made. Under such circumstances anything that promises to shed light on the subject, from whatever point of view, is welcome. Among recent historical works on the subject, the publications of the Johns Hopkins University hold a prominent place, the fifth series of studies in historical and political science published by that institution being mainly devoted to the history of American cities. The opening numbers of the series, treating of the history of Philadelphia and Boston, named above, and give in a brief form the leading events in the municipal lives of those two cities with clearness and with an

eye to practical reform. It is curious to note the great difference between these two municipalities in their origin—Philadelphia having been governed by a close corporation of between twenty and thirty members, while Boston was a pure democracy, which ultimately had over seven thousand voters—and then to trace the steps by which both were converted into cities of the modern type with essentially similar organizations. Various reform measures are described and advocated in both the pamphlets before us; but the perusal of them has only confirmed us in the view we have long held that the evils of city government are due not to defective organization, but to defects in the character of the people, for which the true remedies are educational and moral.

Our thanks are due to Mr. C. C. Vermeule, Topographer of the Geological Survey of New Jersey, for calling our attention to some errors in the summary of the work of the survey which we gave in our October number, and also for furnishing us some facts additional to what are given in the report of the State Geologist. He says: "The notice of the Geological Survey of New Jersey and of the report of the State Geologist for 1886, in the October number, contains several errors which are so important as to call for correction. The topographical survey has been in progress ten years, having been begun in 1877; and will be completed during the present year. The extension of the geodetic survey from the primary chain of triangles, which was thrown across the State about 1840, was begun by Professor E. A. Bowser, Assistant United States Coast and Geodetic Survey, in 1875; and the report in question states that this survey, not the topographical survey, will require two years more for completion. This geodetic work was still further extended by the topographical survey so as to average one station to each twenty-five square miles, the stations being at a distance of five miles apart, and not twenty-five miles, as the notice states.

"The impression is also given that the total area covered by the topographical survey at the date of the report was eighteen hundred and ninety-seven square miles, whereas the report states that this area was covered during the year 1886, and that the only work remaining to be done is the revision of five hundred and seventy square miles. At the date of this communication this work has all been done, and maps of the whole area of the State, on the scale of one inch to a mile, have been published."

A text-book of Volapük, or an easy method of acquiring the new "Universal" language, prepared by Klas August Linderfelt, Librarian of the Milwaukee Public Library, is in press, and will be published immediately by C. N. Caspar and H. H. Zahn & Co., Milwaukee. It has been prepared for the English-speaking public, on the basis of Alfred Kirchhoff's "Hilfsbuch," with a key and dictionaries. It will contain about 120 pages, and will be sold at fifty and seventy-five cents a copy.

A "Hand-book of Volapük" is also announced, by Charles E. Sprague, of 1271 Broadway, New York. It will contain expositions of the grammatical structure of Volapük; progressive exercises; cautions and hints; grammatical analyses; a vocabulary; and a key to the exercises. It can be used for home study, and presupposes only a knowledge of English grammar. Price, $1.

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POPULAR MISCELLANY.

The Proposed Monument to Audubon.—At the recent meeting in New York of the American Association for the Advancement of Science, the fact that the remains of the great naturalist Audubon lie in an obscure and little-visited portion of Trinity Cemetery, New York city, and that his tomb is unmarked by any distinguishing monument, was brought to the attention of the members. The demands upon the time of all in attendance at that meeting were so great, that no action was taken by the Association, although the most lively interest was expressed by individual members, and the propriety of marking the resting-place of the founder of American ornithology by a suitable monument was appreciated. The Audubon plot in Trinity Cemetery will probably be disturbed by the continuation westward of One Hundred and Fifty-third Street. The trustees of the cemetery have, with commendable liberality, assigned the Audubon family a new plot, close to One Hundred and Fifty-fifth Street, in full sight of Audubon Park, and near the end of Audubon Avenue, when this shall be continued from the north, and are in hearty cooperation with the monument enterprise. At the first autumn meeting of the New York Academy of Sciences, a committee was appointed to solicit funds and make all arrangements for a monument. It consists of Professor Thomas Egleston, of

the School of Mines, chairman; Professor Daniel S. Martin, of Rutgers Female College, and Dr. N. L. Britton, of Columbia College. This committee has organized, with Dr. Britton as secretary and treasurer, and is now ready to receive subscriptions, which will be properly acknowledged. Checks should be made payable to N. L. Britton, treasurer, and post-office orders should be drawn on Station H, New York city. The committee estimates that from six to ten thousand dollars will be required to erect and engrave a shaft worthy the memory of America's first naturalist, and, while confident that this amount will be forthcoming, desires to have interest taken in the project by scientists in all departments throughout the country.

The Hills and Valleys of Cincinnati.—Professor Joseph F. James, in a study of the topography of Cincinnati, describes the valley, with its two ancient parallel river-terraces, in which the business part of the city is built, as girt with a line of hills, rising from three hundred and ninety-six feet above low-water in the Ohio River, or eight hundred and twenty-eight feet above the sea, the height of Mount Adams, to four hundred and sixty or eight hundred and ninety-one feet, the height of Mount Auburn. The hills were originally rounded at the top, but have been so marred by the destructive agencies of city "improvements," that they can hardly be recognized. There still remain, however, the great drainage-valleys, which have for ages carried the water from the north, south into the Ohio River. None of them, except Mill Creek, which occupies part of the ancient channel of the Ohio, are of any great extent, and this is one fact tending to prove the former insular character of the suburban parts of Cincinnati. Four of these valleys are mentioned, besides Mill Creek. While they, with their attendant heights, have added greatly to the picturesqueness of the city, they have, at the same time, been taken advantage of in the building up of the suburbs. The heights have been utilized for dwellings, while the valleys between have proved invaluable for streets. The tracing of the divide which separates the Ohio River drainage from that of Mill Creek, is an interesting study. It pursues a general northeast and southwest direction, and can still be followed in quite a definite manner for a part of its course. In two cases instances are observed of two ravines heading up close to one another on both the south and north sides of the divide; and these lend illustration to a remark that has been made by Captain Dutton, that in mountainous countries the ravines form a series of amphitheatres close to a narrow divide which remains sharp in all stages of erosion. The Rev. G. F. Wright, of Oberlin College, has found that the southern foot of the continental glacier crossed the Ohio near Point Pleasant, about twenty-five miles above the city, and recrossed it at Aurora, Indiana, blocking the course of the stream for about fifty miles. Professor I. C. White has estimated the height of this dam at six hundred and forty-five feet above low-water in the river. From the absence of any traces of glacial drift upon the hills, the author doubts if it could have been so high. Besides enlarging upon the beauty of the situation of Cincinnati, which no man can question, Professor James claims for it that, situated on part of the oldest dry land (Cambrian) in the Western world, its site "can boast of an antiquity which puts to shame many more renowned cities," its rocks being "hoary with the age of countless centuries," while the soil of New Orleans is "yet saturated with its baptismal shower"; they were gray with moss when the Devonian site of Louisville was deep under the ocean; when the sub-carboniferous of St. Louis was as yet scarcely even in process of formation; and they vastly antedate the Rocky Mountains and the Mississippi.

A Central Astronomical Agency.—In a paper on "The Extension of Astronomical Research," Professor Edward C. Pickering, of Harvard Observatory, calls attention to the fact, that while the net results of astronomical research have been of enormous pecuniary value, in certain cases large sums of money have been expended with little or no useful return. Striking instances may be mentioned of observatories without proper instruments, large telescopes idle for want of observers, and able astronomers unprovided with means of doing useful work.

The object of his paper is to suggest a way in which this waste of resources may be in part remedied, and in which money may be most advantageously employed for the extension of astronomical knowledge. This way is through the establishment of a central agency to which funds might be sent, to be expended on observatory or other work, so as to attain the best results, independently of all local and personal conditions. No institution appears to be better adapted for such service than Harvard College. It is financially strong; the management of the funds intrusted to it has been excellent; and its officers know perfectly well what are the requirements of scientific work.

The Boomerang.—Several German observers have been studying the boomerang for the discovery of the secret of its curious course of flight. Dr. H. Landois, of Münster, from intercourse with a group of native Australians who were exhibited there, has found that there are larger and smaller boomerangs. The larger ones are slender crescents, about sixty centimetres long, five and a half centimetres wide, and one centimetre thick; plane on the lower side, convex on the upper side, pointed at either end, and sharpened toward the edges. The lower end is cross-grooved, to aid in holding it. The careful manner in which the savages manipulated the weapon, trying its shape, testing its qualities, and scraping it down, is significant of the importance they attach to its having exactly the right curvature. The wood of which the instrument is made is an extraordinarily heavy Australian iron-wood; and the only tools used in making it are sharp stones and pieces of glass. The smaller boomerangs are bent at an angle of 45°, but are in other respects conformed to the larger ones. An exhibition of boomerang-throwing revealed a degree of strength in the natives which was in astonishing contrast with the thinness of their forms. They took the weapon in their right hand, with the flat side downward and the concave side forward, and with a run and a shout, threw it by a short jerk about one hundred yards up into the air. It flew away in a straight line, then turned to the left, and returned in a curved line back to the thrower, whirling around constantly and whizzing unpleasantly. The curve which the weapon describes in its return is not a screw-line or a spiral, but is more like a figure 8. The savages seemed able to control their instrument, even when wind interfered to complicate its course. Once the projectile went astray, and, coming in contact with a gentleman's hat, cut it off as cleanly as a razor would have done. Herr Hermann Froebel, of Weimar, who seems to be a manufacturer of toy-boomerangs, as he speaks of having made eleven thousand specimens of the article, believes he has discovered the mystery of its shape. It is not a crescent or even curvature, but must have a kind of nick or sharper curvature in the middle, with the two arms of unequal length, in the proportion of about four to five. The arms should not be of the same thickness, but the longer one should be pared down so as exactly to balance the shorter one. The correctness of these principles may be verified by adding a very little to the weight of either arm, or by slightly shortening the longer one. The instrument will then no longer answer its peculiar purpose any better than if it were only a common stick. The peculiarity of the motion of the boomerang is due to the difference in the length of the arms, by the operation of which a divergence from the circular is imparted to its curve of rotation. The remarkable feature of the whole matter is that such savages as the Australians should have been able to discover the peculiar properties of this form and apply them. The fact shows what extraordinary powers of observation the people of nature possess. The attempts to give a philosophical explanation of the trajectory of the boomerang variously compare it with the caroming of a billiard-ball, the sailing of a piece of paper or card-board in the air, and the flight of birds.

What is Graphite?—Graphite is not lead, as its names plumbago and "black-lead" would seem to indicate, nor is it a carburet of iron, as some works of scientific pretension still call it. Except that some impure specimens contain about as much iron as ordinary clay, it is the purest form of carbon, the diamond not excepted. Professor W. Mattieu Williams believes that it is nothing else than extremely finely divided

charcoal or soot; and reasons upon the subject as follows: The hand-rails on the staircases of the Metropolitan Railway stations, after some use, become coated with a delicate film of graphite or "black-leaded." The same is seen, but more faintly, on suburban hand-rails, but not at all in rural stations. "Whence comes this graphite film? Why is it developed as we approach the center of London, reaching its maximum in the most densely populated and sootiest regions of the metropolis? My answer to these questions is, that it consists of a selection of the very finest particles of London soot. The hands of passengers in rubbing along these rails conduct a debtor and creditor transaction. There is soot-carbon on the hands and soot-carbon on the rails, as on everything, animate or inanimate, that is exposed to a London atmosphere. Some of the soot-particles on the rails are brushed off by the hands, some rubbed down and smeared on the wood; some are abstracted by the hands, and some are contributed by the hands as additions to the smearing. It is obvious that in such proceedings the coarser particles are those that will be brushed off or carried away, while only the very finest, the impalpably minute particles, will adhere as a black, varnish-like, unctuous film to the hard wood." So, when the coarsest lamp-black or ordinary soot, the finest vegetable-black, and powdered plumbago, are rubbed upon paper, the appearance of the fine black will be found to be intermediate between that of the other two substances.

What the Edible Birds' Nests are made of.—Naturalists have not been able to decide of what material the edible birds' nests are composed. Some have regarded them as made of pure animal secretions; others believe that algæ enter largely into their composition. Mr. E. L. Layard has suggested that the nests of the first quality, or those which are made early in the season, are made of secretion, but that later on, if the first nests are destroyed, the birds can not replace them by this secretion alone, and have to use extraneous substances to help in the construction. Mr. J. R. Green, of the Physiological Laboratory, Cambridge, has examined specimens of the nests of various qualities, and finds them all to become alike gelatinous in texture on soaking, and made up of laminæ affixed by their faces to one another. Some nests of inferior quality showed the presence of algæ, but neither in their mode of disposition nor in the quantity did they confirm Mr. Layard's view. The scanty amount and rregular position of the algæ would be better accounted for on the theory of their being accidental constituents. The nest-substance gave no micro-chemical reactions that could connect it at all with cellulose, so that it could not be formed by the partial digestion of the algæ and regurgitation of the resulting matter. On the other hand, it did give very striking evidence of its close relationship with the substance mucine described by various authors, and well known as a product of the animal body.

Cameos.—Cameos are made from pieces of sea-shell, of which, as every one must have noticed, while the outside is often rough and unseemly, the interior is perfectly polished, and sometimes of a brilliant color. The shells, which are usually of a species of *Cassis* and *Strombus*, natives of the West Indies, are chosen on account of the thickness and hardness of the layers, of the contrast of color between them, and of the presence of knobs on the exterior surface which render it possible to work in relief. When a cameo is begun, a piece of the shell, rather larger than the ornament is intended to be, is cut out and affixed to a holder by a kind of coarse sealing-wax. The inner surface of the shell is of course the lowest, and on the gray outside the master draws a rough outline of the design, and places the work in the hands of an apprentice, who, by means of a file, reduces the knob to the requisite height, removes all the gray matter that lies outside of the boundary-lines, and dresses the whole of the irregular surface. In this condition a cameo looks like an irregular piece of chalk rising out of a small plate of colored glass. It is now returned to the master, who again draws the design in pencil upon it; and from him it passes to another apprentice or workman, who brings out the design with a burin. In late years it has become the fashion to have cameo-portraits taken, but the likenesses, to which the artist usually manages to give a classical

turn, are said to be "often striking, always clever, and generally abominable." The great fault of most modern cameo-cutters is an excessive fondness for detail.

Ground-Water and Health.—Mr. Baldwin Latham, C. E., declares, as the conclusion derived from eleven years of investigation, that there is generally a parallelism between the conditions of health and the volume of ground-water. The years in which there has been a large quantity of ground-water present have invariably been the healthiest years, while those in which there has been a small quantity have invariably been the most unhealthy periods. As a rule, the lowness of the ground-water indicates the future health, and not the state of health at the particular time of lowness; that is, the unhealthy period, as a rule, follows the period of low water, the degree of lowness indicating the intensity of future disease. In some instances an unhealthy period runs concurrently with the period of low water, but in all these cases there is clear evidence that percolation has begun before the unhealthy period comes on. These results, which are confirmed by observations made at Paris, differ from those obtained by Professor Pettenkofer, at Munich, in that he there found typhoid fever and low water concurrent; in all other respects they agree with his. There is also clear evidence, derived from experience in England, that the lowering of the subsoil water by artificial means produces a tendency to the development and dissemination of typhoid fever. It is clear, however, to the author's mind, that ground-water itself has no influence, either for good or evil, upon health, but that the lowness or highness of the water in the ground is the index of conditions which greatly influence the health of all communities. We have periods of abundance of water, and periods of low water, with both healthy and unhealthy conditions. Ground-water has been shown by Professor Pettenkofer to be chemically more impure in periods of high water when the conditions were favorable to health than when there is a low state of the ground-water and a condition unfavorable to health. The records also show that we have periods when rain has started into existence malignant diseases; while, on the other hand, we have similar heavy rainfalls accompanied by a high state of public health. The records clearly point out that it is not one circumstance alone which produces disease, but that there are at least three factors concerned in the matter, especially in the case of typhoid fever, viz.: the elements which produce disease, such as a polluted state of the ground; the conditions which are necessary for the development of disease, such as a period of dryness of the ground in those regions which water usually occupies, combined with a comparatively high degree of temperature; and conditions which will lead to the spread of the disease, such as the probable influence of a storm or rain in driving impurities out of the ground into our water-supplies, or through the instrumentality of ground-air passing into our habitations, and its reception by a population which is in a condition to receive such germs of disease. If any of these conditions is absent, diseases like typhoid do not occur. It has been pointed out by Professor Pettenkofer that in those districts in which the rivers are held up at uniform levels by rains, the conditions are favorable to health, and cholera seldom becomes epidemic. This is corroborated in great measure by the state of health at seaside resorts, which being at the natural outflow for ground-water, and owing to the uniform height of mean tide-level are placed in a condition favorable to health.

Hints in Object-Teaching.—Mrs. Sarah J. Hale, in a little book on "Infant-School Management," gives some excellent precepts for interesting children in subjects of study and making them at home in them. "In every case," she says, "the teacher must bring plenty of illustration to bear upon the lesson. In natural history the real animal, or a picture, should be exhibited, and if possible something that it furnishes us with, as, for instance, the fur of the otter, the shell of the tortoise, the quills of the porcupine. The teacher should also carefully provide herself with pictures of animals which afford strong contrasts to those with which she is dealing, as well as those which bear some general resemblance to it, that she may exercise the discriminative as well

as the assimilative faculty of her pupils. In all object-lessons, various specimens of the object should be produced for examination and description; the little ones themselves must do the main part of the latter under the teacher's guidance, for these lessons are not only to enable the children to form new ideas, but they are also intended to train them in giving expression to such ideas. The teacher must make good use of the blackboard, and should practice drawing objects, so that she may illustrate with facility and precision any particular point of her lesson which can be so illustrated. All the materials, pictures, diagrams, etc., which the teacher provides from time to time should have their place in the school museum ready for future needs, and the children should be encouraged to bring contributions to such a museum, particularly such as the lessons they receive may suggest."

Artificial Production of Minerals.—According to M. Friedel, of the French Association, experimentation in the artificial production of minerals was suggested by the observation of the crystalline products accidentally formed in the metallurgic furnaces. Mitscherlich and Berthier took it up, and it has been advanced by a considerable number of experimenters. MM. Fouqué and Michel Lévy, by melting certain silicates and then exposing the vitreous mass to a lower temperature than that of fusion, have reproduced the identical minerals formed in the eruptive rocks, including the anorthite and labradorite feldspars, amphigene, pyroxene, peridote, and magnetic iron. While the granites have not been produced as such, their constituents—quartz and orthoclase and albite feldspars—have been obtained in crystals. The first essays at reproducing the zeölite groups of minerals have been made by De Schulten, by heating the silicate of soda in tubes of aluminous glass. Spinel and corundum, among precious stones, were long ago produced by Gaudin, Ebelman, H. Sainte-Claire Deville, and Caron; and MM. Frémy and Feil have more recently prepared the ruby in large crystalline masses, which possess all the properties of the natural mineral except the susceptibility for cutting. A new advance seems to have been made in producing rubies, for artificial stones of fair dimensions have been met with in the trade, which, though not as bright and transparent as the natural gems, have their hardness, density, and optical properties. The diamond alone appears to have so far resisted all attempts at reproduction.

Somnambulism. — The phenomena of somnambulism and their connection with the nerve-centers have not been satisfactorily accounted for. They probably depend primarily, says the "Lancet," upon a directing impulse of sensory origin. Some of our actions often become by practice so nearly automatic that partial sleep or stupor does not arrest their unconscious performance. In somnambulism the intellect and the controlling will are torpid, while the sensori-motor man whom they should govern is awake and active. As in dreams the intelligent sensorium is alone drowsily active, with possibly a noticeable tendency to restless movement, so there may be other states of dreaming, in which the centers of motion are stimulated to a more powerful but unconscious action. Partial counteractives to somnambulism may be found in throwing off worries, and in the proper regulation of evening meals.

British Colonial Wines. — Among the features of the Indian and Colonial Exhibition held last year in London, was the department of colonial wines, in which the Australian wines played a prominent part. The soil, climate, and other Australian conditions differing from those to which European vines are subject, have stamped these wines with an individuality, in consequence of which they can never become exact substitutes for those of Europe. The lighter qualities of the Australian wines are believed, however, to be suited for consumption in England, where the commoner wines of France might be found too cold and thin for ordinary use. The phylloxera was discovered in Australian vineyards in 1877, but was checked in a very short time by the application of summary and effective measures. The Cape of Good Hope is capable of producing immense quantities of wine per acre, amounting in some vineyards to nine times the average in France, and four times in

Australia. But the growers seem to have become careless as to the treatment of their vineyards and the quality of the wine they produce, and the exportation has fallen off. A few samples of wines were exhibited in the Canadian court. In late years much attention has been bestowed in Canada upon grape-growing and wine-making; and, in 1881, four million pounds of grapes were raised in the Dominion, of which nine tenths were grown in the province of Ontario. The wines exhibited were found sound and pleasant, and enjoy a local reputation; but they were hardly known outside of the Dominion before the Exhibition.

Qualities of Sewage-Farm Milk.—Dr. Carpenter, of Croydon, denied, during a recent discussion in the Society of Arts, that the milk produced on a farm irrigated by sewage was contaminated or less wholesome than other milk. When he became acquainted with the Croydon sewage-farm, they had difficulty in getting rid of the milk, because of the prejudice against it. But by judicious management the prejudice was worn out. The speaker knew, from personal experience, that the children who took the milk were never troubled with any of those illnesses which were said to be due to bad milk, and there were never any complaints of the milk, which was delivered once a day, becoming sour. That was a proof of its power of being assimilated by the body, and that it was of a perfectly desirable character in point of health, he knew from examination of the families who took it. They had now no difficulty in Croydon with regard to the disposal of their milk from the sewage-farm.

NOTES.

A DISCUSSION and analysis published by Professor F. G. Novy, of Ann Arbor, Michigan, in the "Pharmaceutische Rundschau," go to show that the new anæsthetic, stenocarpine, or gleditschine, which has attracted considerable attention, is nothing but a mixture of cocaine and atropine. More exactly, Professor Novy determines it to consist, essentially, of six per cent of cocaine hydrochloride; fifty per cent of atropine sulphate, and about a third of one per cent of salicylic acid, the latter being used as a preservative.

A CORRESPONDENT in Whitby, Ontario, calls our attention to an omission—of considerable importance in countries liable to extreme cold—which he has observed in Dr. von Nussbaum's article on "Freezing," in the September number of the "Monthly." In the direction for rubbing with snow for the restoration of frozen parts, the author has omitted to state that the snow used should be of a temperature but little, if any, below the freezing-point. It has happened, through ignorance of this particular, that snow has been applied in cases of frost-bite of a temperature some degrees below zero—with the result, of course, of freezing the injured part still more.

IN a public lecture on "Electric Lighting," delivered during the meeting of the British Association, Mr. George Forbes, after remarking that there were probably more than 300,000 arc-lamps in use in the United States, said that the Americans were also getting the start of the English in electric railways and tramways, and generally in the application of electricity to motive-power.

DR. C. H. F. PETERS, Astronomer of Hamilton College, has had conferred upon him, by the President of the French Republic, the cross of an officer of the Legion of Honor, in recognition of the services which he has rendered to science.

MR. C. E. MONROE presented, in the American Association, the results of some experiments, in which blocks of gun-cotton, after having been stamped with certain letters, were exploded, lettered side down, on flat pieces of wrought-iron. When the letters on the blocks were stamped in relief, they appeared in relief on the iron after the explosion; but when they were sunken in the blocks, they also appeared sunken in the iron.

MR. WILLIAM L. WAKELER tells, in the "Scientific American," how he once, in Georgia, saw a snake climb a tree in a very curious manner. The snake was a "coach-whip," and, frightened by the demonstrations of his observer, made a rush for a water-oak, the long branches of which came down to within four or five feet of the ground; "then rising, until he seemed almost to stand on the end of his tail, he shot up like an arrow through the branches, getting his grip entirely by lateral pressure and not by coiling around the branches."

PROFESSOR LOUIS SORET, President of the Swiss Society of Natural Sciences, has remarked on the æsthetic influence of reiterated impressions as illustrated by the repetition of the same design, both in symmetrical forms, and in lined patterns, such as we see in tapestry, furniture, or buildings, whether of the same dimensions or of

dimensions regularly decreasing. It is the same with regular curves; but the æsthetic influence dwells less in the sensation itself than in the conceptions which it gives of a law.

PROFESSORS MICHAELSON and MORLEY gave accounts, in the American Association, of experiments by which they sought to measure the relative velocity of the luminiferous ether and the earth. Their method was to determine the interference between two beams of light, which were reflected back and forth a number of times; one being in the direction in which the ether was supposed to be moving, and the other at right angles to that direction. No effect was found, and it was concluded that the ether must be at rest with regard to the earth. This solution, however, has to encounter difficulties, and invites further research.

GENERAL PERIER and his Spanish associate, General Ibanez, have presented their report on the surveys for the geodesic and astronomical junction of Algeria and Spain across the Mediterranean, by which the measurement of the arc of the meridian is completed for 27°, or from the Shetland Islands to Laghouat in Algeria. The independent geodesic operations executed in Spain and Algeria are shown by the results to have been very precise. It is also shown that the transmission and reception of rhythmic luminous signals conveying the time from one station to another are capable of great exactness.

DR. HAIN, of Zürich, read a paper at the Swiss Society of Natural Sciences last year on the deformations which fossils undergo in mountains through the enormous pressures to which the rocks are subjected. By them Agassiz was misled into distributing the fossil fish of the older rocks into eighty distinct species; while many of these supposed species were really identical, but deformed in such various ways as to appear different.

PROFESSOR MEES, discussing, in the American Association, the velocity of tornadoes, mentioned that straws and bits of hay are often driven like darts into pine boards, and even into the dense bark of hickory-trees. He had found that to obtain similar results by shooting straws from an air-gun, velocities of from one hundred and fifty to one hundred and seventy-five miles an hour were necessary.

DR. R. W. SHUFELDT has a portrait of Audubon which the great naturalist himself painted, with the aid of a mirror. He has had the portrait photo-engraved, and has prefixed the copies to a paper which he has published giving accounts of this and other mementos of Audubon.

IT is doubtful whether death in burning buildings is as horrible as is generally supposed. "The Lancet," speaking particularly of the affair of the Opéra Comique in Paris, observes that the burning seldom occurs in these cases until after death, or at least insensibility to pain, has been produced. Except under very peculiar conditions, the victim is made faint and pulseless by the carbonic acid, or the carbonic-oxide gas, before the fire reaches his body. It is the experience of persons who have been in a burning house that the heated and smoky atmosphere speedily induces a feeling of powerlessness and of indifference to what is going on around; and it is generally this stupefaction, with subsequent paralysis of feeling, that prevents judicious means being taken for escape.

M. E. LAVASSEUR, of Paris, has shown, by comparing the statistics of 1789 with those of the present, that chances of living long at any given age are greater now than they were before that year. The proportions are, for the survival of infants under one year, as 1,460 now, in every 2,000, to 1,186 then; for living to be forty as 1,110 to 738; and for living to be seventy-five, as 360 to 144.

OBITUARY NOTES.

PROFESSOR KIRCHHOFF, the discoverer of the spectrum analysis, died in Berlin in October, aged about sixty-three years. He was born in Königsberg in 1824, and came to the University of Berlin as a *privat docent* in 1837. In 1850 he was called to the chair of Physics at Heidelberg, where, with Bunsen, he prosecuted the researches which have given him a world-wide and lasting renown. He removed to Berlin in 1875.

DR. JOHANNES SKALNEIT, President of the German Union of Analytical Chemists, and editor of the "Repertorium für Analytische Chemie," is dead. He was the author of many essays and other short works on questions of sanitary science, state medicine, and chemical analysis, and was an authority on analyses of milk and butter.

THE death is reported of Dr. Johann Krejci, Professor of Botany in the University of Prague, and a member of the Bohemian Parliament.

DR. HENRY WILLIAM RAVENEL, botanist to the South Carolina State Department of Agriculture, died in Aiken, July 17. His speciality was fungi. He was best known by his "Fungi Caroliniani Exciccati," of which he issued a number of pamphlets; by his "Fungi Americani Exciccati," which he prepared in conjunction with Dr. M. C. Cooke; and by the papers which he published on the botany of his State.

CLEVELAND ABBE.